PARTHENIUM MEDIATED SYNTHESIS OF ZINC OXIDE NANOPARTICLES AND ITS CHARACTERIZATION

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Objective: To biosynthesize zinc oxide nanoparticles by using parthenium hysterophorous plant extract as a reducing agent and its characterization by spectroscopic techniques.

Methods: A novel method was developed to prepare zinc oxide nanoparticles by using zinc nitrate as a precursor and biosynthesis of zinc oxide nanoparticles was mediated by parthenium hysterophorous plant extract without the aid of external energy (high pressure and temperature). This new method involves simple techniques such as centrifugation, filtration, and stirring. Zinc oxide nanoparticles formation was confirmed by analytical techniques such as UV-Visible spectroscopy, powder X-ray diffraction (XRD), Raman spectroscopy and by scanning electron microscopy (SEM) analysis.

Results: Zinc oxide nanoparticles were synthesized by using parthenium hysterophorous plant extract as a reducing agent. The XRD measurement showed that zinc oxide nanoparticles possess a typical hexagonal structure and the crystallite size of the synthesized zinc oxide nanoparticles was found to be 32 nm calculated by scherrer’s formula. The SEM images show aggregation of zinc oxide nanoparticles that are spherical clusters. The maximum absorbance (380 nm) of UV-Visible spectroscopy further confirmed synthesized nanoparticles are zinc oxide. The Raman spectra show both E2 mode and E1 mode, which indicates that the prepared zinc oxide nanoparticles possess crystalline nature with hexagonal wurtzite structure.

Conclusion: A method was established to prepare zinc oxide nanoparticles with parthenium hysterophorous plant extract which is a novel approach without the aid of external energy (high pressure and temperature), and formation of zinc oxide nanoparticles was confirmed by spectroscopic techniques. This method can be used in pharmaceutical industry for the synthesis of an antimicrobial agent.

Keywords: Zinc oxide, Nanoparticles, Parthenium hysterophorous, Raman spectra

INTRODUCTION

Zinc oxide has attracted much attention due to exceptional electronic and optical properties for various technological applications, because of its wide band gap (3.2-3.7 eV) [1]. They also have remarkable potential application in the field of medicine like biological activities such as antimicrobial, antioxidant, etc.

There is a growing interest to prepare different type of nanoparticles by environmentally friendly methods that do not use toxic materials in the synthesis procedures. [2–7] Synthesis of metal oxide nanoparticles using the medicinal plant extract is quite novel, which is effective at an affordable cost, [8–12] without any external energy (high pressure, energy, temperature).

The medicinal plant parthenium hysterophorous (Feverfew) is traditionally used for vast pharmacological applications (such as treatment of fevers, migraine, headache, infertility, etc.). Among Greek and early European herbalists, the parthenium herb has a long history of use in traditional and folk medicine. Parthenium hysterophorous plant extract and zinc oxide both have antimicrobial properties. Based on the above facts, Parthenium hysterophorous plant was selected with zinc oxide metal particle for green synthesis of zinc oxide nanoparticles. The objective of the study was to establish an easy method for biosynthesis of zinc oxide nanoparticles by using parthenium hysterophorus plant extract and its characterization by spectroscopic techniques.

The rationale for the study is its pharmaceutical use as an antimicrobial agent. Easy method for synthesis without the aid of external energy such as high pressure and temperature. This study is a novel approach that describes the easy synthesis of zinc oxide nanoparticles without heat treatment, using parthenium hysterophorous plant extract. These zinc oxide nanoparticles were characterized by spectroscopic techniques for the confirmation of the formation of zinc oxide nanoparticles. This research study provides an established method for biosynthesis of zinc oxide nanoparticles which can be used as an antimicrobial agent in the pharmaceutical industry.

MATERIALS AND METHODS

Parthenium hysterophorus plant material

Flowers and leaves of parthenium hysterophorus plant were collected from Indira park and public gardens, Nampally, Hyderabad. Parthenium hysterophorus plant of family Asteraceae was identified by the Department of Botany, Sri Venkateswara University, Tirupati with voucher number 1216. The plant was identified based on the leaves, lobed with fine soft hair, flowers on the top are small creamy colored with black colored seed. Based on the features of the plant it was confirmed as parthenium hysterophorus.

Preparation of parthenium hysterophorus plant extract

After the identification of the plant, the leaves and flowers were separated from the plant. The leaves and flowers were dried under dark and shady conditions, without exposing the material to sunlight. After drying, leaves and flowers were powdered in a mechanical grinder, and the fine powder was collected by passing through sieve no 40. This powder is stored in a cool and dry place until its use. Plant powder was extracted in a number of solvents such as methanol, hexane, anhydrous sodium sulfate, acetone, chloroform, diethyl ether. Of all the solvents used, acetone is considered as the best solvent for the extraction of the compound from the leaves and flowers of parthenium hysterophorus plant.

50 g of powdered parthenium hysterophorus plant material was weighed and carefully transferred into the round-bottomed flask of Soxhlet extractor. Then 250 ml of acetone was added, and the plant
material was soaked in acetone for 24 h at room temperature. Then the acetone extract of the plant was filtered using Whatman no 1 filter paper. This supernatant is taken in a separate beaker. This crude extract was used only for further analysis.

**Bio-synthesis of zinc oxide nanoparticles with *parthenium hysterophorous* plant extract**

A quantity of 1g of *parthenium hysterophorous* plant extract was dissolved in 100 ml of de-ionized water and centrifuged for 15 min and filtered. Zinc nitrate 0.75g (0.1 M) was used as the precursor for the preparation of zinc oxide nanoparticles. 40 ml of the extract of *parthenium hysterophorous* was added dropwise in zinc precursor while stirring using a magnetic stirrer. In order to adjust the pH = 12 of the solution, sodium hydroxide (NaOH, 1 M) was added drop-wise while stirring. A white crystalline precipitate of zinc oxide was obtained, which is washed 2-3 times with de-ionized water, filtered and dried to obtain the zinc oxide nanoparticles.

**RESULTS AND DISCUSSION**

**Characterization of zinc oxide nanoparticles**

a. **Powder X-ray diffraction**

XRD was taken to examine the crystal structure and phase purity of synthesized zinc oxide nanoparticles using the extract of *parthenium hysterophorous* plant without annealing. Fig. 1 shows the corresponding XRD pattern and below bars are the hexagonal phase. As can be seen from the fig. of the obtained XRD pattern consists of dominant peaks are consistent with the zinc oxide hexagonal phase (standard joint committee on powder diffraction standards [JCPDS] card no. 36-1451) [13]. The *parthenium hysterophorous* plant extracts contains phytochemicals helps in the synthesis of metal oxide nanoparticle by inducing oxidation and reduction reaction. Further, the pattern shows a line broadening which indicates the crystallite size reduced.

The crystallite size of the material was calculated using the Scherrer’s formula:

\[
\delta = \frac{K\lambda}{\beta \cos \theta}.
\]

Where \( \delta \) is the crystallite size, \( K \) is the dimensionless shape factor (0.94), \( \lambda \) is the X-ray wavelength, \( \beta \) is the full-width half maxima (FWHM) and \( \theta \) is the Bragg’s angle. The crystallite size of the synthesized ZnO was found to be 32 nm.

**b. Scanning electron microscopy**

The SEM images show agglomeration of zinc oxide particles (fig. 2(a)). The magnified image is shown in fig. 2(b), it appears to be some of the particles are spherical. Fig. 2 represents the morphology of the as-synthesized zinc oxide nanoparticles prepared by using *parthenium hysterophorous* plant extract. Typical SEM images of the zinc oxide nanostructures at two different magnifications are shown in fig. 2(a) and (b). It is clear from the lower magnification image that the as-synthesized zinc oxide nanoparticles are spherical clusters in a large-scale area and have approximately uniform morphology. Fig. 2(b) shows the higher magnification image of such spherical particles surrounded by amorphous *parthenium hysterophorous* plant extract.

**c. UV–visible spectroscopy**

UV–visible absorption spectrum as showed in fig. 3, is carried out to evaluate the potential optical properties of the as-prepared zinc oxide nanoparticles using *parthenium hysterophorous* plant extract. For the UV–visible absorption measurement, the as-prepared zinc oxide nanoparticles using *parthenium hysterophorous* plant extract sample is ultrasonically dispersed in absolute ethanol before the examination, using absolute ethanol as the reference. The spectrum was corrected for the solvent contribution. The absorption spectrum of zinc oxide nanoparticles using *parthenium hysterophorous* plant extract shows well-defined excitation band at ~ 401.5 nm, which is shifted by ~28 nm relative to the bulk zinc oxide excitation band (~373.5 nm). The calculated band gap of ~3.09 eV of these nanoparticles is less than that of the band gap of bulk zinc oxide (3.3 eV). The reason for the shifting of the absorption band could be due to the oriented attachment of the nanoparticles by using *parthenium* extract may lead to defect formation in these zinc oxide nanoparticles. Similar observations for shifting of absorption bands of zinc oxide towards the visible region were also reported earlier [15]. Surface area and surface defects play an important role in the photocatalytic activities of metal oxides. Additionally, it affects the optical and electronic properties due to which the optical absorption shifts towards the visible region. For the effective use of zinc oxide, band gap has to be minimized from 3.38 eV to below 2.0 eV, since it is the recommended band gap value for achieving a visible-light active photocatalyst [16].

However, pure zinc oxide phase acts as an efficient photo catalyst only under UV irradiation. One of the strategies adopted for tuning
CONCLUSION

A novel eco-friendly method was established to synthesize Zinc oxide nanoparticles without the aid of external energy. Formation of these nanoparticles was confirmed by spectroscopic techniques. Zinc oxide nanoparticles is a proven antimicrobial agent with minimal effect on human cells. Hence the established method can be further scaled up for zinc oxide nanoparticle synthesis for pharmaceutical use.

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AUTHORS CONTRIBUTIONS

All the authors have contributed equally

CONFLICTS OF INTERESTS

Declared none

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