International Journal of Pharmaceutical Research and Applications
Volume 7, Issue 3 May-June 2022, pp: 1702-1705 www.ijprajournal.com ISSN: 2456-4494

Green synthesis and characterization of Zinc Oxide nanoparticles from the leaf extract of Saccharum Spontaneum

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Submitted: 01-06-2022 Revised: 14-06-2022 Accepted: 16-06-2022

ABSTRACT
The field of biologically produced nanomaterials has grown in importance in recent years. The current study described the manufacture of zinc oxide nanoparticles (ZnO NPs) from saccharum spontaneum leaf aqueous extract. UV-visible spectroscopy, X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), and transmission electron microscopy analyses were used to characterise the nanoparticles (TEM). The greatest peak in the UV-visible spectra of ZnO NPs was found at 370 nm. XRD measurements revealed the crystalline character of the ZnO NPs.

Keywords: ZnO NPs, Green synthesis, XRD, FT-IR, Antimicrobial activities.

I. INTRODUCTION

Nanotechnology is an emerging subject of science that is exploding in popularity. Nanoparticles offer unique optical, electrical, and designs based not seen in single molecules. Nanoparticles are synthesized using a variety of metals, including silver, gold, aluminium, zinc, carbon, titanium, iron, and copper. Metal nanoparticles are used in a variety of fields, including medicine, electronics, biosensing, and biotechnology [1].They can be synthesised using a variety of physical and chemical methods, but they are not preferred due to a number of drawbacks, including the use of hazardous chemicals, lengthy and complex processes, heat, pressure, and energy demands, and significant problems in huge quantity. Green synthesis, or the creation of nanoparticles using plant extracts, is an appealing option. Green methods are easy, environmentally friendly, cost-effective, nontoxic, and so on.

Biosynthesis of ZnO NPs by plants such as Aloe barbadensis miller leaf [2] brown marine macro alga Sargassum muticum [3] seaweeds of gulf of Mannar [4] Aeromonas hydrophila [5] Trifoliate orange (Poncirus trifoliata) [6] and Parthenium hysterophorus [7] have been reported.

In this work we have used Saccharum spontaneum for green synthesises of nano-particles. Saccharum spontaneum (wild sugarcane, Kans grass) is a grass native to the Indian Subcontinent. It is a perennial grass, growing up to three meters in height, with spreading rhizomatous roots.Kasha-Saccharum spontaneum is a herb mentioned in Ayurveda for the treatment in conditions of burning urination, renal calculi, menorrhagia, bleeding piles and to improve the quantity of breast milk in lactating women.

The ZnO nanoparticles are generated in this study employing a cost-effective, easy, and environmentally friendly technique. For the cost-effective creation of ZnO nanoparticles, an environmentally friendly technique with large-scale manufacturing and no undesirable contaminants is preferred. As a result, low-cost precursors like zinc nitrate hexahydrate and natural products like Saccharum Spontaneum are employed in a straightforward green way to synthesis ZnO nanoparticles. Antimicrobial activity of produced ZnO nanoparticles is also evaluated against a variety of human pathogenic microorganisms.

II. MATERIALS AND METHODS

Materials

Fresh leaves of Saccharum Spontaneum free from disease were collected early in the morning during the month of July. Chemicals and glassware were procured from Sigma Aldrich.

Synthesis of zinc oxide nanoparticles using Saccharum Spontaneum leaf extract

The leaves were disinfected with double-distilled water after being rinsed thoroughly 2-3 times under running water. The leaves were allowed to dry at room temperature (32°C), and 20 g were collected for synthesis. 20g of leaves were weighed and cooked in 100 mL of double distilled water for 20 minutes at 60°C. The extract was filtered with Whatman No. 1 filter paper and stored in the refrigerator.

A standard technique was used to extract 20 mL of aqueousSaccharum Spontaneum extract from the stock solution (stored at refrigerator). Later, using a magnetic stirrer, 2g of zinc nitrate hexahydrate

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crystal was dissolved in the A. indica extract solution. After the combination had completely dissolved, the solution was heated at 60-80 °C with a magnetic stirrer until a deep yellow coloured paste was formed. The paste was placed in a ceramic crucible cup and fired in a furnace for 2 hours at 400 degrees Celsius. The light-yellow powder produced was used for future research. Figure 1 depicts the flowchart for the production of ZnO nanostructures.

Analytical methods

Characterization of the synthesized ZnO NPs was carried out by various spectroscopy techniques like UV-Vis spectroscopy,zeta potential, thermal gravimetric analysis (TGA), fourier transform infrared (FTIR) spectroscopy, X-ray diffraction analysis (XRD), andtransmission electron microscopy analysis (TEM).

III. RESULTS AND DISCUSSION

UV-visible Spectroscopy and Zeta Potential Analysis

Absorption spectrum is used as a preliminary method to confirm nanoparticle production. Due to its surface plasmon resonance, the synthesised ZnO NPs displayed a prominent absorbance peak at 370 nm (Fig. 1a), confirming the production of ZnO NPs from Saccharum Spontaneum leaf extract. According to the zeta potential, the surface charge of produced ZnO NPs was 16.63 mv (Fig. 1). It was concluded that nanoparticles were positively charged and stable as a result of this.

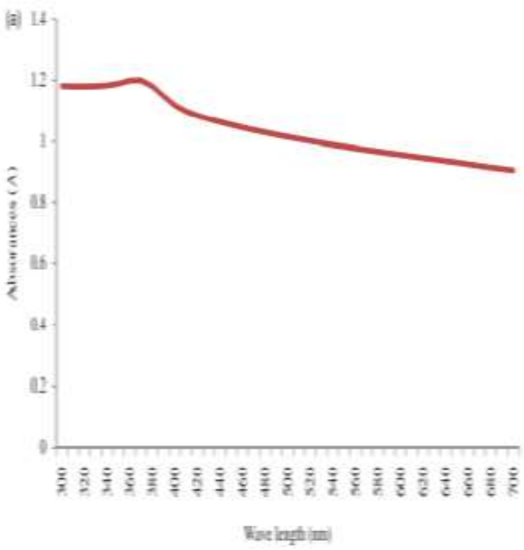

Fig. 1. UV-visible spectroscopy ofZnO NPs.

Thermal Gravimetric Analysis

TGA was used to assess the relative composition of the organic capping agents present on the surface of nanoparticles. TGA curve of synthesized ZnO NPs is given in Fig. 2. TGA curve showed steadily weight loss in temperature range 0–800 °C. The TGA analyses of ZnO NPsrevealed 1.7% weight loss at about 100 °C which is attributed to desorption or removal of moisture and 31.7% weight loss of its total weight at 400 °C indicating a thermal decomposition of plant bioorganic molecules present on the surface of ZnO NPs.At temperatures above 500 °C there was no weight loss in the TGA curve, indicating that the ZnO NPs were stable within this temperature range.

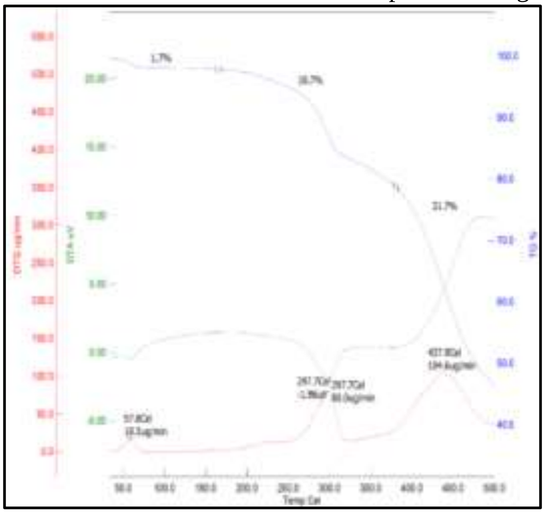

Fig. 2. TG-DTA plot of ZnO NPs.

Fourier transform infra-red spectroscopy (FTIR)

The FTIR spectra of saccharum spontaneum leaf extract (Fig. 3)has shown absorption bands at 3352 and 2924 cm^{-1} representing O−H and C−H stretching of polyols. The absorption peak is located at around 1647 cm^{-1} represented C=C stretching vibrations of aromatic rings. Stretching vibrations present at 1452 and 1251 cm−1 are associated with O−H and C−OH vibrations of polyols, respectively. Stretching vibrations are located at 1045 and 663 cm^{-1} represented C−N stretching and N−H was of amines, respectively. Small bands at 1734 and 1386 cm^{-1} are represented C=O stretching vibrations of carboxylic acid.The peaks in the region between 600 and 400 cm^{-1} are allotted to M–O(Zn-O).The band at 457 cm^{-1} confirms stretching vibrations of zinc oxide NPs.

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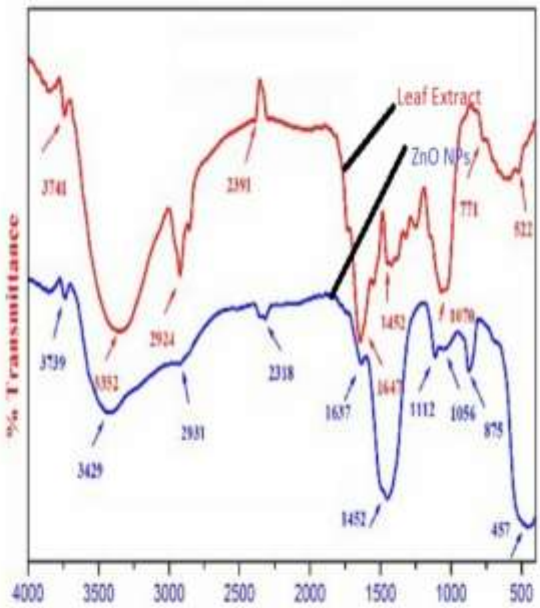

Fig. 3.FTIR spectra of leaf extract andZnO NPs.

XRD analysis

X-ray diffraction (XRD) patterns of zinc nanoparticles synthesized using aqueous extract of saccharum spontaneum leaf at room temperature indicate that the structure of zinc nanoparticles is face-centered cubic (fcc) (Fig. 4). XRD analysis showed three distinct diffraction peaks at 2 theta values of 15.49°, 15.80° and 15.80°. The sharp, strong and narrow diffraction peaks in the XRD pattern indicated that the synthesized ZnO NPs were crystalline in nature.

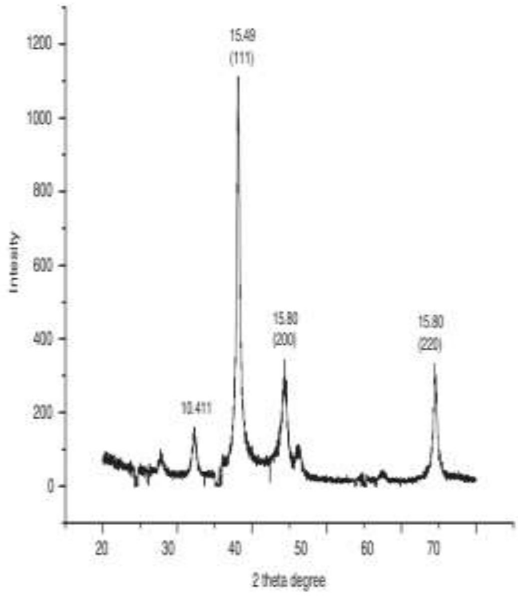

Fig. 4. XRD spectrum of biosynthesized ZnONPs.

Transmission electron microscopy analysis (TEM)

Fig. 5(a, b) shows the size and shape of ZnO NPs as determined by TEM examination at various magnifications. The size of ZnO NPs was shown by TEM to be in the range of 12.47 nm to 26.97 nm, with an average size of 17.33 nm. The form of ZnO NPs was mostly spherical and irregular, with a well-defined morphology.The size of the generated ZnO NPs was less than that of ZnO NPs synthesised by Aloe barbadensis and Citrus aurantifolia extracts previously reported; the sizes were 25 to 40 nm and 50 to 200 nm, respectively. Fig.5 shows the Selected Area Electron Diffraction (SAED) pattern of ZnO NPs (c). The SAED image's ring-like diffraction pattern suggests that the particles are entirely crystalline in structure, having symmetric ZnO NP alignment.

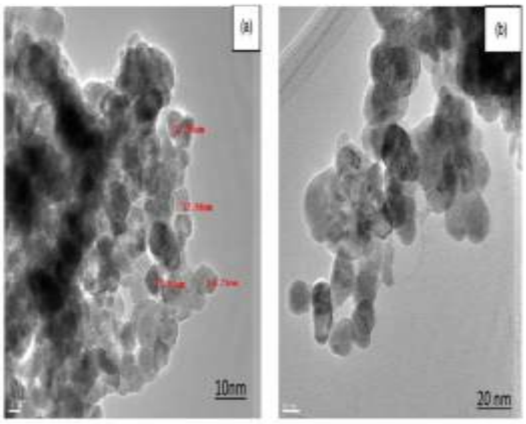

Fig.5. TEM images of ZnO NPs.

IV. CONCLUSION

The present study successfully demonstrated a safe, simple, eco-friendly method for the synthesis of stable ZnO NPs by Saccharum Spontaneum leaf extract. The spectroscopic characterizations using various analytical techniques confirmed the formation of ZnO NPs.

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