A NOVEL GREEN SYNTHESIS ROUTE TO ZnO NANOPARTICLES: RED BANANA PEEL-MEDIATED SYNTHESIS AND MULTIANALYTICAL CHARACTERIZATION

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ABSTRACT

This study presents the green synthesis of ZnO nanoparticles using Red Banana peel extract as a natural reducing and stabilizing agent. X-ray diffraction (XRD) confirms the formation of highly crystalline ZnO with a crystallite size of 32 nm. Fourier-transform infrared (FTIR) spectroscopy identifies functional groups from Red Banana peel, indicating enhanced stability and bioactivity. The synthesized ZnO nanoparticles demonstrate promising applications in photocatalysis for environmental remediation, antibacterial coatings, and solar energy conversion. This eco-friendly approach highlights the potential of ZnO nanoparticles for sustainable and multifunctional applications.

KEYWORDS: ZnO Nanoparticles, Red banana peel, green synthesis, XRD, FTIR.

INTRODUCTION:

Zinc oxide (ZnO) nanoparticles possess unique physicochemical properties, including strong UV absorption, high photocatalytic activity, chemical stability, and antimicrobial performance. These attributes make them useful in cosmetics, pharmaceuticals, ceramics, sensors, environmental remediation, and optoelectronic devices. Conventional synthesis methods such as sol–gel, precipitation, and hydrothermal techniques can produce high-quality ZnO nanoparticles but often involve toxic reagents, high temperatures, and energy-intensive processes, leading to environmental concerns. Green synthesis has emerged as a sustainable alternative, employing plant extracts and agricultural waste as natural reducing, capping, and stabilizing agents. Such materials contain bioactive compounds—polyphenols, flavonoids, proteins, and carbohydrates—that facilitate nanoparticle formation without harmful chemicals. Red banana peel, an abundant agro-waste, is rich in carbohydrates, amino acids, and antioxidants, making it an effective and eco-friendly synthesis medium. This study investigates the green synthesis of ZnO nanoparticles using red banana peel extract, aiming to develop a cost-effective, scalable, and environmentally safe production method.

MATERIALS AND METHODS:

Fresh red banana peel was taken, washed several times with tap water and Cut into many pieces. The cut Red Banana peel and distilled water were combined in 1:10 ratio For extraction process. This solution covered with aluminum foil and boiled at 70℃ hot plate for 30 min and stirred at 1000 rpm. Light Brown banana peel extract was obtained and this extract was cooled At room temperature. This extract was filtered using filter paper and stored at 4℃. 21.95g of zinc acetate dihydrate mixed with 100 ml of distilled water. It was then stirred at room temperature about 45 min at 700 rpm. 10 ml of banana peel extract mixed with 90 ml of zinc acetate dihydrate. It is then stirred at room temperature about 1 hour 30 min at 700 rpm. The pH value of the solution is maintained at 12 by dropwise addition of NaOH. This solution was stirred at room temperature about 1 hour at 400 rpm. Next day, white precipitate was obtained. The precipitate was filtered and dried in hot air oven at 100℃ for 2 hours. White colour ZnO nanoparticles was thus synthesized.

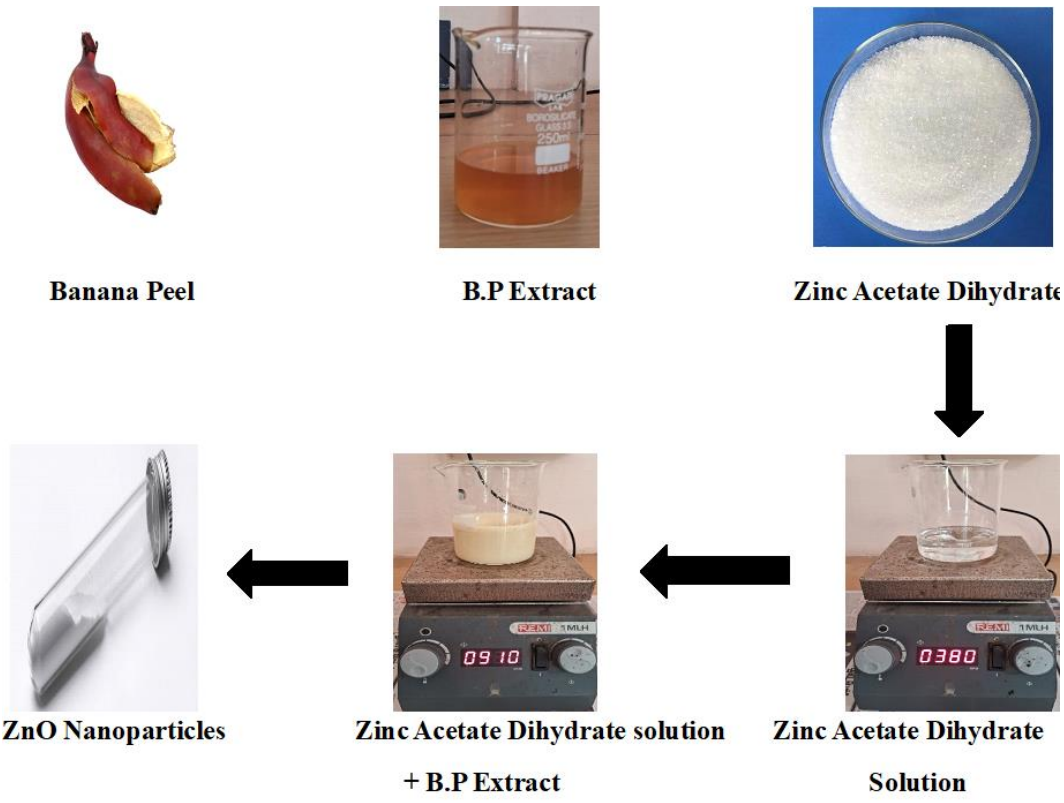

Fig: 1 Synthesis of ZnO Nanoparticles using Red Banana Peel

RESULT AND DISCUSSION:

The X - ray diffraction (XRD) pattern of the as-prepared sample was studied using X-ray diffractometer with Cu Kα radiation of wavelength 1.5405Å. XRD diffraction graph for the as-synthesized sample is shown in the figure 2. Diffraction peaks at the positions of 31.7°, 34.4°, 36.2°, 47.5°, 56.6°, 62.8°, 66.3°, 67.9°,69°, 72.5°and 76.9° correspond to (100), (002),

(101), (102), (110), (103), (200), (112), (201), (004), (202) planes, respectively, which are in good agreement with the standard JCPDS card no. #6-1451 for hexagonal wurtzite ZnO[2]. The average crystalline Size D is 32 nm was calculated by the Debye Scherer equation. The calculated lattice constants were a=b=3.242Å and c=5.205Å[3].

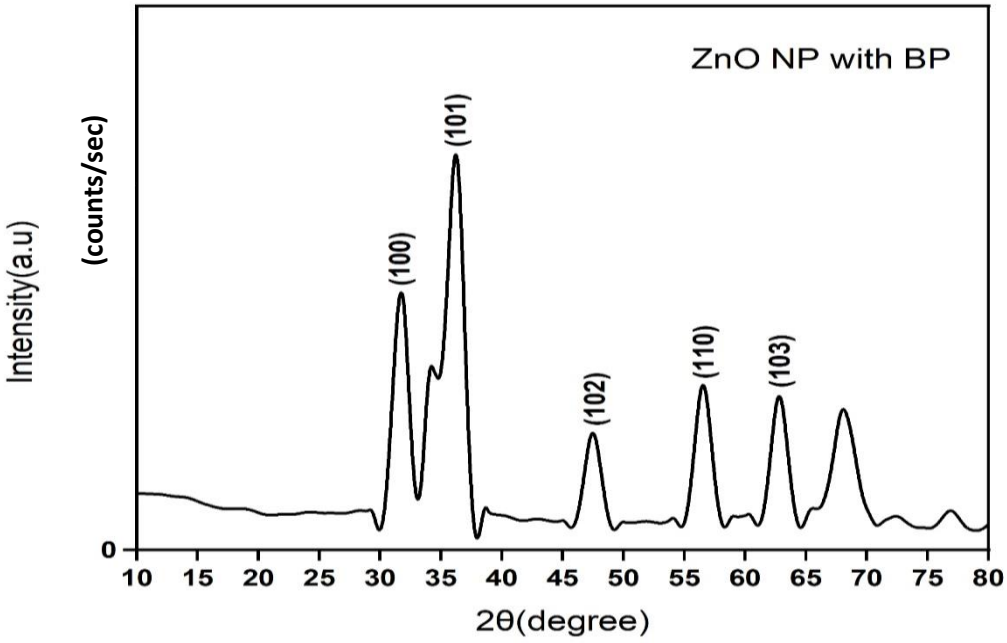

Fig: 2 XRD pattern of ZnO Nanoparticles

The Fourier Transform Infrared Spectroscopy was used to identify the functional groups of the active components. X-axis represent the vibrational modes of chemical bonds in the sample. The range is 4000 cm^{-1} to 400 cm^{-1}, which covers most functional group vibrations. The y-axis represents how much infrared light passes through the sample. Lower transmittance at a specific wavenumber indicates absorption due to molecular vibrations. The peak 460-750 cm^{-1} represent the Zn-O bond stretching vibrations, confirming the presence of ZnO nanoparticles. The peak 1141-1566 cm^{-1} represent C-H bending, C=C stretching, or other organic functional groups. The peak 2368 cm^{-1} represent CO_2 absorption from the atmosphere. The peak 3464-3873 cm^{-1} represent O-H stretching, indicating the presence of hydroxyl (-OH) groups, which could be due to adsorbed water or surface hydroxylation. The spectrum confirms the presence of ZnO nanoparticles due to the Zn-O vibrational peaks[4].

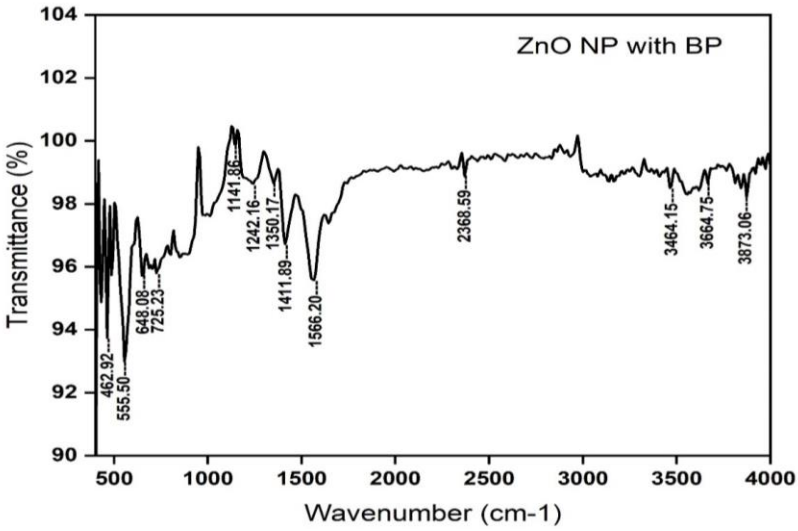

Fig: 3 FTIR spectra of ZnO Nanoparticles

CONCLUSION

XRD confirms the crystalline nature of ZnO nanoparticles with a crystallite size of 32 nm.FTIR spectroscopy identifies the functional groups present, indicating interactions between ZnO and bioactive compounds from Red Banana peel, which may enhance its stability and functionality. These are the effective for environmental remediation, such as wastewater treatment and air purification. The biofunctional properties from Red Banana Peel make them promising for antibacterial coatings, wound healing, and drug delivery.Their optical properties make them suitable for solar cell enhancements and sensor technologies.

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