EXPLORING THE STRUCTURAL AND OPTICAL PROPERTIES OF GREEN SYNTHESIZED ZnO NANOPARTICLES FROM POMEGRANATE PEEL

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ABSTRACT

This study explores the eco-friendly synthesis of ZnO nanoparticles using pomegranate peel extract as a natural reducing and stabilizing agent. X-ray diffraction (XRD) analysis confirms the formation of highly crystalline ZnO with a crystallite size of 35 nm. Fourier-transform infrared (FTIR) spectroscopy detects functional groups from the pomegranate peel, suggesting improved stability and bioactivity. The resulting ZnO nanoparticles exhibit significant potential for applications in photocatalysis for environmental purification, antibacterial coatings, and solar energy conversion. This sustainable method underscores the versatility and promise of ZnO nanoparticles for various green and multifunctional uses.

KEYWORDS: ZnO Nanoparticles, Pomegranate Peel, Green Synthesis, XRD, FTIR.

INTRODUCTION

Zinc oxide (ZnO) nanoparticles are a class of metal oxide nanomaterials with unique structural, optical, and antimicrobial properties. Due to their high surface area, biocompatibility, and multifunctionality, they have gained significant attention in biomedical, environmental, and industrial applications. While green synthesis of ZnO nanoparticles has been widely explored using plant extracts such as Aloe vera, neem, and Moringa, very few studies have specifically investigated the use of pomegranate peel extract [1]. Pomegranate peel is often overlooked despite its rich phytochemical profile, making it a novel and underexplored biosource for ZnO nanoparticle synthesis. Most ZnO synthesis studies focus on leaves, flowers, or fruit extracts, while peels—which are often discarded as waste—have been less frequently utilized [3].

MATERIALS AND METHODS

To prepare the plant extract, fresh pomegranate peels were taken.To remove the dust particles and unwanted particles, the pomegranate peels were washed with tap water twice and then was cleaned with the distilled water and cut it into small pieces. 12.5g of pomegranate peel and 100 ml of distilled water were mixed for extraction process. This solution covered with aluminium foil and boiled at 70°C hot plate for 15 min and stirred at 400 rpm. Ligh t brown solution was obtained and this solution was cooled at room temperature. This solution was filtered using Whatmann filter paper. 21.949 g of zinc acetate dihydrate mixed with 100 ml of distilled water.It was then stirred at room temperature about 30 min at 400 rpm. 10 ml of extract mixed with 90 ml of zinc acetate dihydrate.The pH value of the solution is maintained at 12 by dropwise addition of NaOH (Sodium hydroxide).The solution is then stirred at room temperature about 2 hours at 700 rpm. The white-coloured solution with precipitate was obtained. The precipitate was filtered and dried in hot air oven at 100°C for 3 hours. White coloured ZnO nanoparticle was thus obtained.

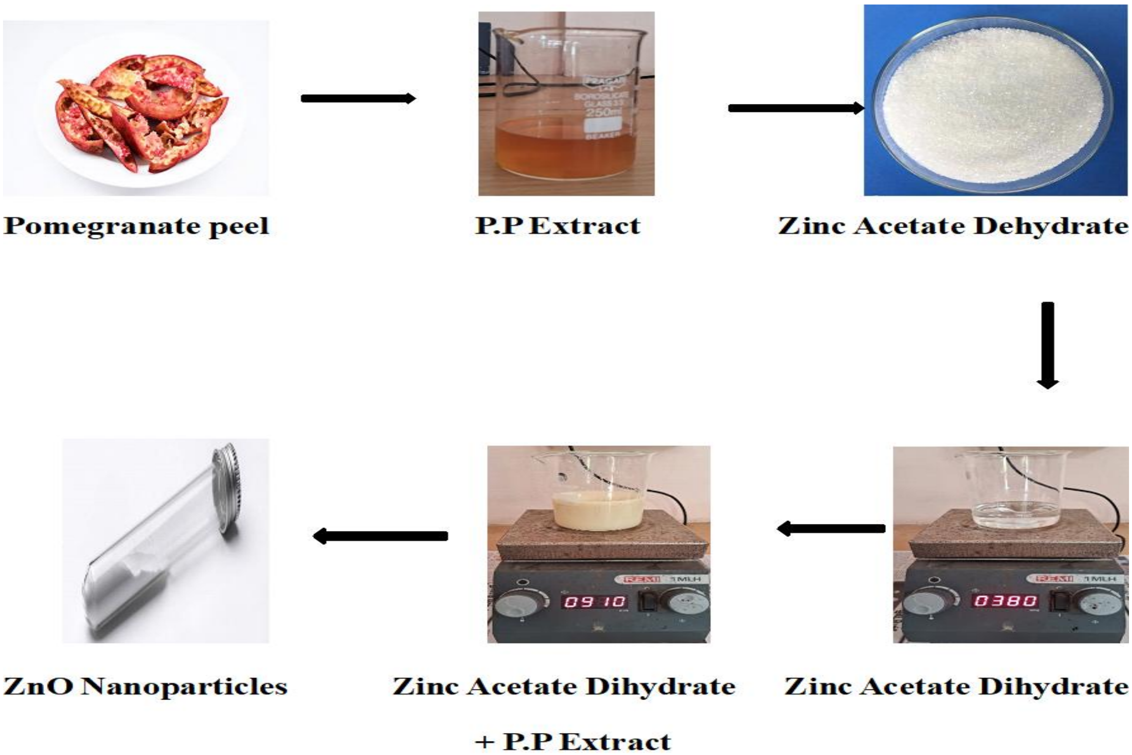

Fig: 1 Synthesis of ZnO Nanoparticles using Pomegranate peel

RESULT AND DISCUSSION

The structural characterization of ZnO nanoparticle are carried out by XRD method. Figure shows that X Ray diffraction spectrum of the synthesized ZnO nanoparticles using the pomegranate extract. The indexed diffraction peaks shown in the figure 2represent the hexagonal wurtzite structure of ZnO with lattice constants of a = b = 3.242 Å and c = 5.205 Å[2]. The average crystallite size D is 35 nm was calculated by using the Debye Scherer equation.

The XRD results for the ZnO nanoparticle exhibit strong peaks around 2 theta are 31.72, 34.42, 36.24, 47.49, 56.53, 62.81, 66.28, 67.86, and 68.99 corresponding to the reflection from (100), (002), (101), (102), (110), (103), (200), (112), and (201) crystal planes, respectively[3]. The strong intensity and narrow width of ZnO diffraction peaks indicate that the resulting products were of high crystalline. No diffraction peaks from other species could be detected in the XRD pattern.

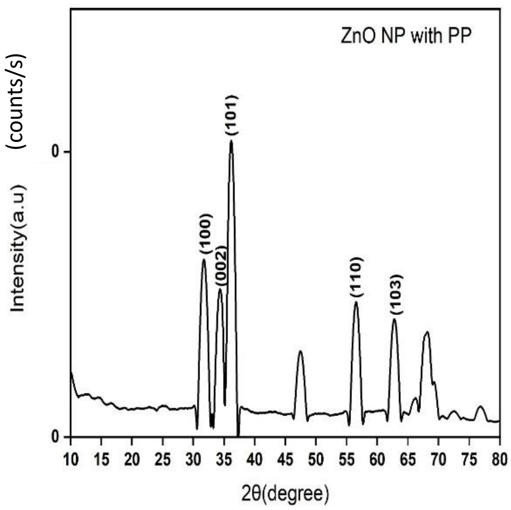

Fig: 2 XRD pattern of ZnO Nanoparticles

Sample	2 Theta (degree)	FWHM	d spacing	hkl planes	Crystalline size (D) nm	Average crystalline size (D) nm
ZnO	31.7230	0.1968	2.82071	100	39.77349	35.90543
	34.3668	0.1968	2.60953	002	39.77357	
	36.1980	0.2362	2.48161	101	33.13908	
	47.4834	0.3149	1.91483	102	24.85721	
	56.5205	0.2362	1.62825	110	33.13980	
	62.7674	0.1968	1.48039	103	39.77485	
	66.2818	0.1968	1.41017	200	39.77505	
	67.8664	0.2362	1.38105	112	33.14035	
	68.9738	0.1968	1.36155	201	39.77522	

Table: 1 Average crystalline size of ZnO Nanoparticles

The Fourier Transform Infrared Spectroscopy was used to identify the functional groups of the active components. In figure 3 X-axis represents the frequency of infrared light absorbed by the sample, ranging from 500 cm^{-1} to 4000 cm^{-1}. Y-axis indicates how much IR radiation passes through the sample without being absorbed. The spectrum confirms the presence of ZnO nanoparticles, as indicated by the Zn-O vibration peaks. The peak 455.20 – 594.08 cm^{-1} represent the Zn-O bond stretching vibrations, which confirm the presence of ZnO nanoparticles. The peak 725.23 cm^{-1} represent C-H out-of-plane bending, common in polymer structures. The peak 1411.89 cm^{-1} & 1558.48 cm^{-1} represent C=C stretching or aromatic ring vibration. The peak 3417.86 cm^{-1} & 3618.46 cm^{-1} represent the O-H stretching vibrations, indicating the presence of hydroxyl (-OH) groups, possibly from adsorbed water or surface hydroxyl groups on ZnO nanoparticle[4].

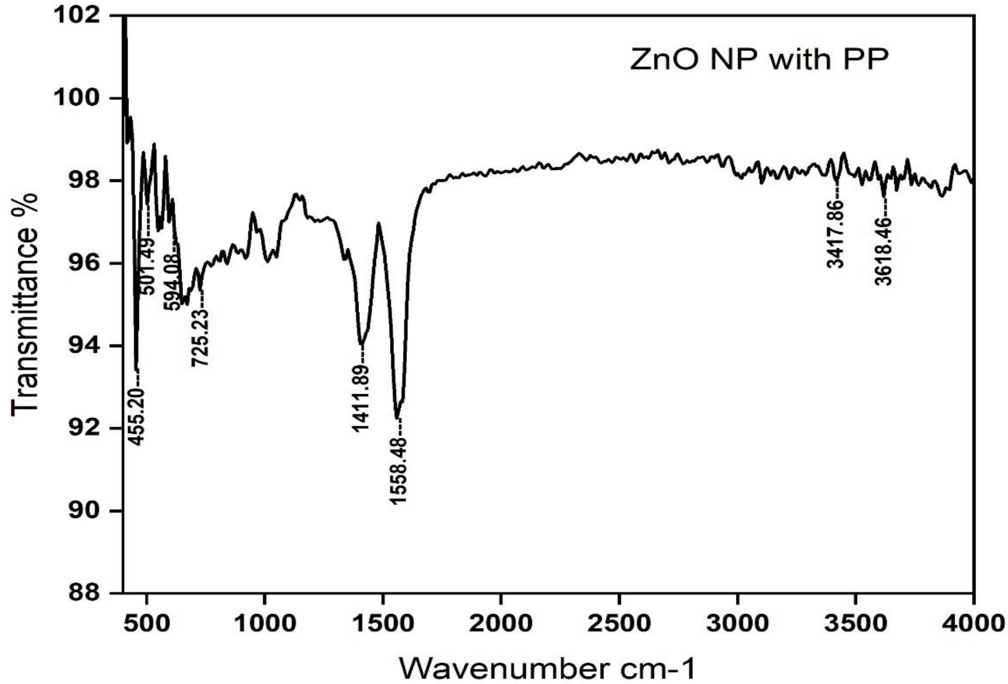

Fig:3 FTIR spectra of ZnO Nanoparticles

CONCLUSION

XRD confirms the crystalline nature of ZnO nanoparticles with a crystallite size of 35 nm. FTIR spectroscopy identifies the functional groups present, indicating interactions between ZnO and bioactive compounds from pomegranate peel, which may enhance its stability and functionality. These are effective for potential application, biomedical uses, renewable energy.

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