Green Route Synthesis Approach to extract Zinc Oxide (ZnO) Nanoparticles Using banana leaves

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Abstract : Metal oxide nanoparticles have wide range of applications in the field of sensing from past decades as the researchers are working on it and have reported the same. In this paper the synthesis of ZnO nanoparticles using banana leaves has been considered using green synthesis approach using solution combustion method to extract ZnO. The green synthesis approach reduces the toxicity level and is not harmful when compared to the commercial ZnO nanoparticles which are synthesized using chemical approach. The as-synthesized metal oxide nanoparticles were then characterized by X-ray Diffraction (XRD), UV-Visible Spectroscopy (UV-Vis), Fourier Transform Infrared spectroscopy (FTIR) and Scanning Electron Microscope (SEM). The synthesized ZnO nanoparticles were confirmed with size of 18nm.

Index Terms - Zinc oxide [ZnO], Green synthesis, Banana leaves, Metal oxide nanoparticles.

I. INTRODUCTION

The field of nanotechnology is very versatile covering almost all existing branches of science. Studies on biological effects of nanoparticles in higher plants are increasing day-by-day [1]. It is framed as 21st century science, as it has tremendous applications in the various fields like physics, chemistry, material science, biology. Recent advances in the field of nanotechnology, particularly the ability to prepare highly ordered nanoparticles of any size and shape, have led to the development of new biocidal agents. The synthesis of metal oxide nanoparticles has attracted the attention of scientists in various fields particularly in biological, medical, optical and mechanical sciences. The high surface area and fractions of atoms/molecules of the metal nanoparticles are the main reason for their unique properties such as catalytic, electronic and magnetic activities. The metal oxide nanoparticles are usually synthesized by various physiochemical Methods like Chemical reduction, laser ablation, solvo-thermal, inert gas condensation and sol-gel method are being followed for the synthesis of zinc oxide nanoparticles but these methods are energy consuming, they make use hazardous solvents and expensive reagents and, needs attention to maintain parameter and are very toxic. Metal and metal oxide nanoparticles are usually synthesized by various physiological methods [2]. Design of processes that reduces or eliminates generation of hazardous substances is the key principle for sustainable chemistry. Developing green method for synthesizing nanoparticles is a major focus so as to reduce the toxicity and the green synthesis approach makes use of various leaf extracts [3]. It is eco-friendly and less hazardous when compared to all the physiochemical process. ZnO is an attractive semiconductor material due to its abundance, chemical stability, and lack of toxicity, a wide band gap, large exciton binding energy (60meV) at room temperature. Green synthesis approaches are gaining interest circumventing the high costs and usage of toxic chemicals harsh conditions for reduction and stabilization[4]. It has several applications due to its unique physical and chemical properties. It is employed for manufacturing of optical devices or laser diodes. ZnO also exhibits antibacterial, anti-fungal and UV filtering. It is widely used in many industrial areas such as solar cells, UV light emitting devices, and gas sensors, photo catalytic, pharmaceutical and cosmetic industries. Among the metal oxide nanoparticles, zinc oxide is interesting because it has vast applications in various areas such as optical, piezoelectric, magnetic and gas sensing[8]. This procedure requires Zinc nitrate as a precursor ($Zn(NO_3)_2$), ethanol (C_2H_5OH) as organic solvent and leaf extract as precipitating agent.

II. EXPERIMENTAL

i. Materials

The Synthesis of zinc oxide nanoparticles (ZnO-NP) involves the use of zinc nitrate ($Zn(NO_3)_2$) as precursor from Sigma-Aldrich, DI water and banana leaves.

ii. Preparation of Piper banana leaf extract

The banana leaves were initially washed for about 3-4 times with tap water followed by DI water to remove dust particles from the leaves. Then the leaves were immersed inside the beaker with 100ml of DI water. The leaves extraction was obtained with the help of magnetic stirrer under continuous stirring maintaining 90^0C for 3hours. The light green color changes of the DI water is the sign of indicating that extraction was obtained.

iii. Green synthesis of ZnO using leaf extract

The synthesis of ZnO nanoparticles under normal condition is done by solution combustion method using banana leaf extract. Initially 0.1M ratio of Zinc nitrate ($Zn(NO_3)_2$) (0.1M) was added to the DI water of 20ml under continuous stirring and then drop wise the leaves extract of 20ml was added to the same solution. The solution was kept under stirring for 30mins. The resultant solution was then transferred to silicon crucible and heated at 750℃ using heating mantle until the solution turned into powdered form. The obtained ZnO powder was further calcinated in hot air oven for 1 hour at 10℃ and later the fine powder of ZnO nanoparticles was obtained by grinding using agate mortar.

III. RESULTS AND DISCUSSION

i. X Ray Diffractometer

The average particle size was calculated using XRD pattern. The diffraction crests showed up at 31.74º, 34.39º, 36.22º, 47.49º, 56.54º, 62.79º, 66.31º, 67.88º, 69.02º, 72.48º, and 76.88º, having (100), (002), (101), (102), (110), (103), (200), (112), (201), (202), and (104) planes of the zincite structure of hexagonal in fig a. The peaks are very much connected with JCPDS-79-2205. The normal precious stone size was observed to be 40 nm

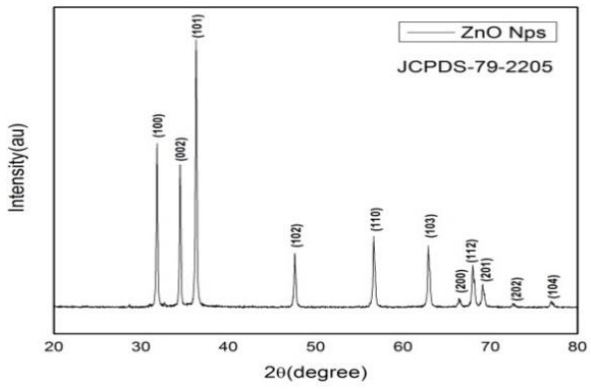

Fig a. XRD of ZnO

ii. Scanning Electron Microscope (SEM)

SEM is an electronic microscope which is used to determine the external morphology of the obtained ZnO nanoparticles. Mixed surface morphology is determined by the obtained SEM images. The ZnO NPs so formed were accumulated with mixed morphology structures with irregular shapes. The structure and morphology of SEM images are shown in fig b. The structures of ZnO nanoparticles can be clearly observed with magnification of 1 μm.

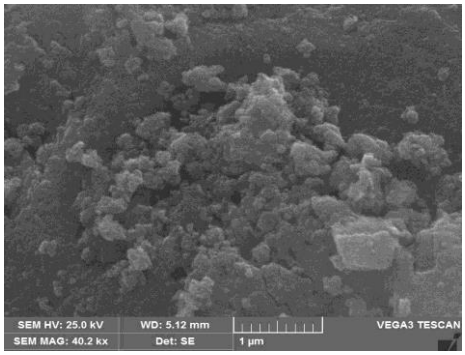

Fig b. SEM of ZnO

iii. Fourier-Transform Infrared Spectroscopy (FTIR)

The powder sample of zinc oxide nanoparticles functional groups were analyzed by using Fourier transform infrared spectroscopy (Perkin–Elmer 1725)[5] as shown in fig c. The FTIR gives data on the vibrational and rotational methods of movement of a particle what's more, henceforth an imperative strategy for recognizable proof and characterization of a substance. The Infrared range of a natural compound gives an exceptional unique finger impression, which is promptly recognized from the retention examples of all different mixes; just optical isomers retain in the very same way. Subsequently FTIR is an imperative system for recognizable proof and portrayal of a substance. Absorption fingerprint region for metal oxide in FTIR is below 1000 $cm^{-}1$. In the above figure peak 874 $cm^{-}1$ indicates the presence of zinc oxide. Amongst all the single bond strongest peak was observed at the wavelength 1416 cm−1 indicates O-H bending. At 2050 cm−1 represents the strongest. double bond C=C with asymmetric stretch. At 2162 cm−1 shows the C≡C symmetry which reduces the intensity.

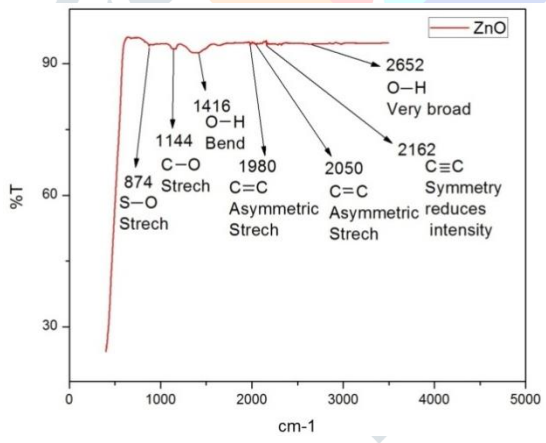

Fig c. FTIR of ZnO

iv. UV-Visible Spectroscopy (UV-Vis)

The optical properties of green synthesized ZnO nanoparticles measured by UV-Visible spectroscopy are as shown in Fig d. The curve of absorbance vs wavelength has been plotted from the absorbance values. It exhibits a strong absorption band at about 355 nm. An excitonic absorption peak is found at about 258 nm due to the ZnO nanoparticles which lie much below the band gap wavelength of 358 nm (Eg=3.46 eV). It is also evident that significant sharp absorption of ZnO indicates the monodispersed nature of the nanoparticle distribution.

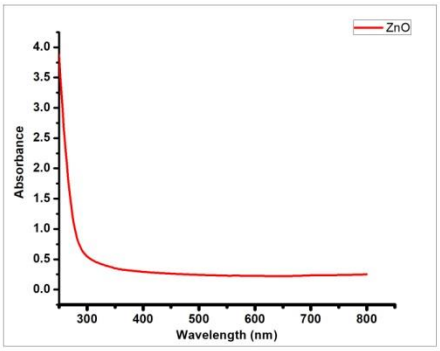

Fig d. UV-Vis of ZnO

IV. CONCLUSION

The synthesis of ZnO nanoparticles using the green synthesis approach using the banana leaf extract using the solution combustion method is very simple, cost effective, eco-friendly, non-toxic, less hazardous when compared to the other physiochemical approach. The synthesized ZnO was then characterized using XRD for obtaining perfect peaks, SEM to obtain the morphology of ZnO nanoparticles, FTIR to find out the functional groups.

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