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Synthesis and Characterization of ZnO Nanoparticles using Mint Plant leaves

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ABSTRACT: In the past few years, the nanoparticles (NPs) transition metals have been investigated widely for their effective role in biological system, medicine, pharmaceutical and food industries, and in the degradation of dyes or other wastes from contaminated surface water. Consequently, in the present work, we have reported the synthesis and characterization of ZnO NPs using two different precursors, Zinc acetate di-hydrate and Zinc nitrate hexa-hydrate by employing mint plant leaves extract method at temperature 60 ^{0}C. Characterization of synthesized NPs has been carried out by UV-Visible, XRD and TEM spectral analysis techniques. XRD confirms the crystalline structure of the ZnO NPs, with 29.03 and 32.29 nm crystallite sizes for Zinc acetate and Zinc nitrate precursors, respectively. However, in both the cases, the spherical shape of ZnO NPs has been resulted from the TEM studies.

Keywords: Nanoparticle; mint plant; zinc oxide

INTRODUCTION

The tailoring of material at the size range of 1-100 nm, nearer to their atomic level is come under the study of a well-known field nanotechnology [1] and the particles in this range are known as nanoparticles (1nm=10^{-9}cm). Study of particles at the nano size range is of great interest and importance due to their large surface area to volume ratio. This property changes the physical and chemical aspect of NPs with respect to the bulky particles [2-3]. The field of Nanotechnology is growing day by day due its wide application in the daily routine of human life either in medicine, agriculture, clothing, cosmetics food processing electronics etc. Nanotechnology has incredible approach in the field of physics, chemistry and biology [4-7].

Metal nano oxides have attracted the researchers due to their ability to withstand under harsh condition and safe to humankind [8]. In order to approach the metal oxide nanoparticles huge number of synthetic method and procedure have reported in the literature for the synthesis. Generally, nanoparticles synthesized by variety of chemical methods. Chemical methods have its own advantages and disadvantages. Disadvantages in the chemical method are in difficulty to scale up the synthesis process, high cost, high-energy consumption, require separation and purification technique and toxic by-products. So developing novel green or biological methods for NPs synthesis is an importance site of work, to minimize the use of toxic chemicals and make the reaction eco-friendly. Green synthesis gives the low cost reaction and stable NPs product in comparison to the chemical methods, [9-11, 2]. Therefore, Green or biosynthesis is an alternative to the chemical synthesis. There is growing attention to the biosynthesis of metal nanoparticles using organisms (fungi, bacteria, plant). Among these organisms, plants seem to be the best candidates and plant extracts have been suggested as possible eco-friendly material, for the large-scale biosynthesis of nanoparticles [12].

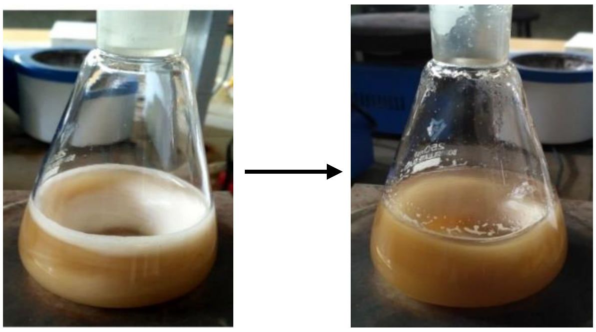
Among all metal NPs, zinc oxide nanostructures are at the forefront of research due to their unique properties and widespread potential applications, in solar cells, piezoelectric devices, UV absorbers, pharmaceutical, agricultural and cosmetic industries [13-14] etc. Different plants have been used for the green synthesis of ZnO NPs in the literature, like Nyctanthes arbortristis, Punica granatum, Aloe Vera, Sesbania grandiflora, Zingiber officinale, Ixora Coccinea, green tea, lemon etc. Various structures of nanometric ZnO have been examine so far with classification. Zinc oxide can occur in one-dimensional (1-D) form as nano rods, needles, helixes, springs, rings, ribbons, tubes, belts, wires, combs etc., Two- dimensional (2-D) form as nanoplate, nanosheet, nanopellets etc. and three-dimensional (3-D) structures with the form of flower, snowflakes, coniferous urchin-like structure [15]. Moreover, NPs are durable and show great selectivity and resistance to heat [16] also these are nontoxic and biocompatible to humans [17]. Zinc nano particles are employed for the removal of Alizarin red from aqueous solution by the catalytic action of nanoparticles [18]. ZnO NPs also show good photocatalytic activity against degradation of methyl orange, methyl red and methyl blue dyes solution [19]. ZnO NPs show good antibacterial, antimicrobial and cytotoxicity activity. Anticancer activity results of ZnO nano powder against breast cancer cell line MCF-7, give a convenient approach in the biological activities [20].

In the present work, we are reporting the green synthesis of ZnO NPs, with two metal precursors Zinc acetate di-hydrate and Zinc nitrate hexa-hydrate to reduce them to ZnO NPs with mint plant leaves extract at 60^0C. The ZnO NPs synthesis approved by UV, XRD and TEM spectral analysis.

MATERIALS AND METHODS

Preparation of plant extract: Mint leaves collected, weighted (10 gm) and washed with distilled water to remove the impurities. Washed leaves boiled for about 15 minutes with 100 ml distilled water. Boiled Extract cooled and filtered through Whatman filter paper. Filtered, obtained plant extract used for the synthesis of ZnO nanoparticles, extract stored in refrigerator for further study.

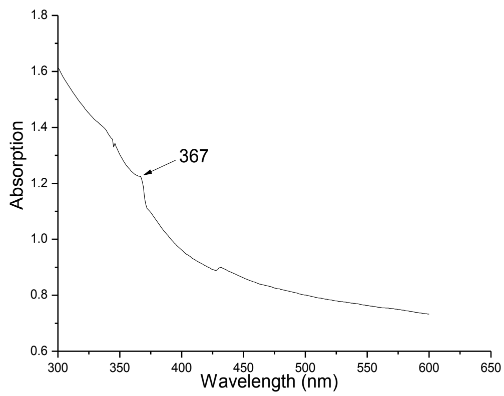
Preparation of ZnO NPs: 10 mmol solution of the Zinc acetate di-hydrate and Zinc nitrate hexa-hydrate were prepared in the distilled water and the prepared solution reduced with the prepared plant extract with 9:1 ratio. Prepared 10 mmol solution of the metal precursor were keep at 60 ^{o}C under constant stirring, as the solution temperature is reached at 60 ^{o}C plant extract is added drop wise to the reaction and then stand the reaction for 2 hour with constant stirring and heating. Formation of NPs was confirm by the change in color of the reaction solution and UV characterization study, synthesized NPs washed several time with distilled water and ethanol. Particles were dried in hot air oven at 50-60^0C and further characterization were done.



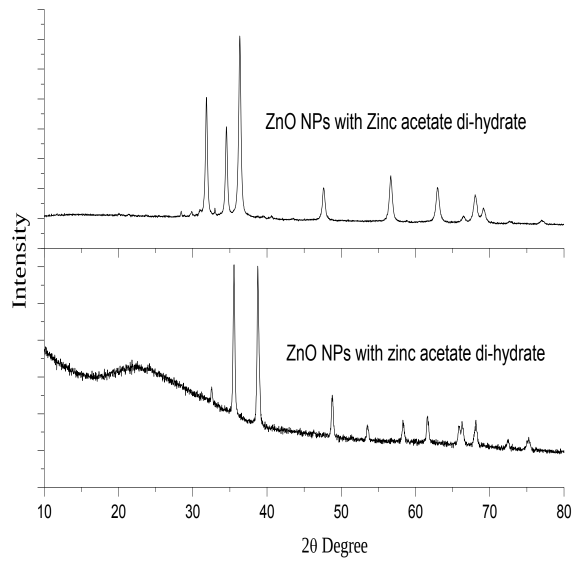
(i) (ii)

Figure 1: Color of the zinc acetate di-hydrate solution (i) After mixing (ii) After 2 hours

The synthesis of ZnO NPs examined by the change in the color of the reaction and an absorption peak of ZnO NPs in the UV region at 367 nm for both samples. To examine the crystallinity of the synthesized ZnO NPs, powder XRD of product examined at 1.54 Å in the range of 10 to 80 degree. Figure 2 shows the XRD pattern of ZnO NPs. Peaks in the spectra indicate the crystalline nature of sample. The 2θ values of the peaks in spectra conform the wurtzite structure of ZnO NPs crystals and its phase purity, as there are no extra peaks is absorbed in the obtained data, matched to the reported literature data. The obtained crystallite size for Zinc acetate di-hydrate and Zinc nitrate hexa-hydrate metal precursors were 29.03 and 32.29 nm, respectively.



(i)



(ii)

Figure 2: (i) UV-Vis spectra and (ii) XRD patterns of synthesized ZnO NPs

Morphology of the synthesized ZnO NPs examined by the TEM spectral images given in Figure 3**.** TEM images of the ZnO NPs shows that the particles are spherical in shape with the particles size of 60-160 nm.

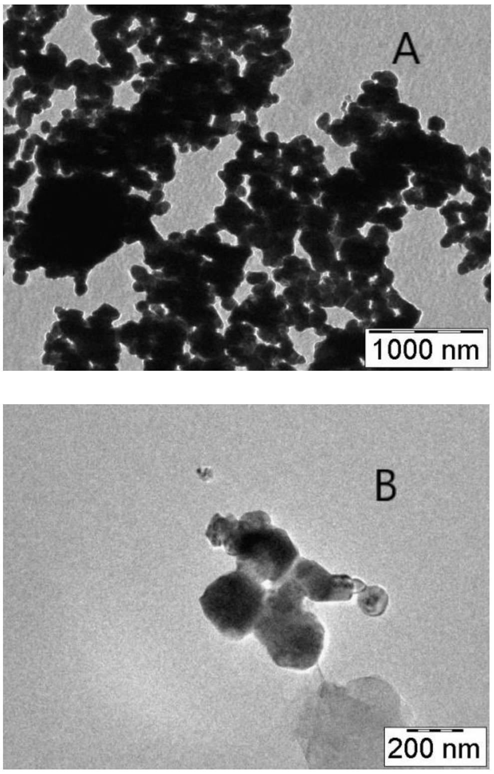


Figure 3: TEM images of ZnO NPs by using precursors (A) Zinc acetate di-hydrate and (B) Zinc nitrate hexa-hydrate

CONCLUSIONS

In the above work we reported the ZnO NPs synthesis with the two different metal precursor Zinc acetate di-hydrate and Zinc nitrate hexa-hydrate. Both the precursors found ambient for the ZnO NPs synthesis with mint plant at low temperature and ordinary reaction condition with the particle size of 60-160 nm having 29.03 and 32.29 nm crystallite size for Zinc acetate and Zinc nitrate metal precursors respectively. This synthesis provides an eco-friendly NPs synthesis method at low cost, fast and nominal reaction parameters.

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