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Biosynthesis And Characterization Of Zinc Oxide Nanoparticles Prepared Using Aloe Vera Leaves Extract

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ABSTRACT
This research work discusses the biosynthesis of zinc oxide nanoparticles using Aloe vera leaves extract. This green method of nanoparticle synthesis is advantageous because it is cost effective and has no negative environmental impact. This synthesis was carried out in solution and the formation of the Zinc oxide nanoparticles was observed by colour change. The FTIR spectrum of the nanoparticles showed sharp bands at about 435 cm^{-1} and 491 cm^{-1} which can be attributed to ZnO stretching bands. The band at 1313 cm^{-1} corresponds to C-N stretching bonds of amines while the band at 3275 cm^{-1} corresponds to O-H stretching of phenolic compounds both arising from the plant extract. The SEM images showed that the nanoparticles are semi-spherical in morphology. The XRD pattern of the nanoparticles showed four strong peaks due to reflections from the (111), (220) (311) and (331) planes of the ZnO at angles (2θ) of 24.50º, 30.40º , 32.60º and 45.20º respectively for a hexagonal wurtzite crystal lattice. The particle size of the nanoparticles was determined to be 48.0 nm using Debye Scherer's equation. This confirms the green synthesis of ZnO nanoparticles using plant extract which can be used for different applications.

Key words: *Aloe vera, biosynthesis, Zinc oxide, nanoparticles and leave extract*

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I. Introduction

Nanoparticles are particles with very small size and dimension that has its range from 1 nm to 100 nm (Laurent et al; 2008). Nanoparticles are particularly suitable for application such as been anti-oxidants, antibiotics, anticancer and other biomedical uses. This application are possible because of their large surface to volume ratio, small size, magnetic, optical, mechanical and chemical properties (Tenase et al, 2019). Many noble metals such as gold, silver and platinum, metal oxides such as Zinc oxide, Silver oxide and metal sulfide such as Copper sulfide and Silver sulfide have all been synthesized for various application due to their unique properties (Behboodi et al, 2019). These nanoparticles were mostly synthesized using chemical and physical methods that uses or produces hazardous chemicals that were not environmentally benign and exhibits some level of toxicities (Gengan et al, 2013). Recently, more attention has been directed towards plant mediated synthesis of nanoparticles due to its eco-friendliness, low cost, less toxicity and ease of synthesis especially in large scale. Plant extracts are particularly suitable for this synthesis because the contain many compounds such as polyphenols, terpenoids, flavonoids, tannins, alkaloids, polysaccharide, amines, ketones and other metabolites that acts as reducing, capping and stabilizing agents in the production of the desired nanoparticles (Rajan et al, 2015). Among all the metal oxides nanoparticles, ZnO nanoparticles are one of the most utilized due to it large band gap, high purity, excellent thermal and chemical stability, unsaturated surfaces and excellent adsorption behavior towards organic and inorganic pollutants (Jinhuan et al, 2018).

Aloe vera is a succulent, perennial and xerophytes plant which has water storage tissue in its leaves. It is made up of a very soft moist and highly viscous slippery tissue in the innermost part of its leaves. The leaves which holds water in its viscous mucilaginous fluid consist of a large thin walls of parenchyma cells. This attribute enable the plant to survive in harsh weather conditions. *Aloe vera* leaves also contains monosaccharide such as glucose and mannose, vitamins, minerals, polysaccharides and phenolic compound together with other organic acids (Amar et al, 2008; Hamman, 2008). These phytochemicals present in the plant are responsible for the stabilization of Zinc oxide NPs. Therefore this work is aimed at the biosynthesis and characterization of zinc oxide nanoparticles using *Aloe vera* leaves extract.

II. MATERIALS

No 1 whatman qualitative filter papers, volumetric flask 500 ml, conical flask 600 ml, ml 100 ml, measuring cylinder 1000 ml, beaker 600 ml, funnels, Magnetic stir bar, Analytical weighing balance (Adams equipments Ltd. Model; AE 7813 for weighing), pH meter (Hanna instruments Romania Model; HI98017), Hot

plate (Stuart Ltd Model; SB106 used for heating), An electrical laboratory oven (Gen Lab Ltd), Cheshire Model (OV/100/ used for drying), Speed adjusting multi-purpose vibrator (HY-2 Ltd), Laboratory grade zinc acetate dihydrate (Spectrum chemical MFG, CROP (99.9% purity)), Sodium hydroxide (LOBA Chemie Pvt. Ltd. (98% purity)) distillated water and *Aloe vera* plant extract.

III. METHODS

Plant Extract Preparation

The obtained *Aloe vera* plant was washed to remove dust and other impurities; it was allowed to dry at room temperature to remove water from the leaves surfaces. The leaves were slice using a knife and a spoon was used to scoop the gel from the leaves. About 250 mL of the extract was dissolved in 200 mL of distilled water and properly stirred, filtered and was then transferred into a 500 mL volumetric flask. It was filled to the marked and then ready for the synthesis.

Preparation of zinc acetate solution

Fifty (15) grams of analytical grade zinc acetate dihydrate was weighed using analytical weighing balance and then transferred into a 250 mL volumetric flask containing 100 mL of distilled water. It was well stirred to ensure that the zinc acetate is completely dissolved. The volumetric flask was filled to the marked with distilled water and the concentration was determined to be 0.30 mol/ L.

Preparation of sodium hydroxide solution

Four (4) grams of NaOH was weigh and dissolved in a 500 mL volumetric flask containing 200 mL of distilled water. It was shaken to ensure that the sodium hydroxide was completely dissolved and then the volumetric flask was filled to the marked and the concentration was determined to be 0.2 mol/L.

Biosynthesis of ZnO NPs from *Aloe vera* extract

A fifty (50) mL of 0.30 M of zinc acetate $Zn(CH_3COO)_2$ solution was dissolved in fifty (50) mL of the prepared plant extract and the pH of the mixture was determined to be 5.7, the mixture was thoroughly mixed using a magnetic stir bar at 800 rmp at 80 °C in a water bath for 2 hrs, 0.2 M of sodium hydroxide solution was added in drop wise to maintain a pH 12, the required pH for the formation of ZnO NPs (Manasa et al, 2020) [9]. After 2 hrs, the solution was left undisturbed for another 2 hrs. A precipitate was formed which was filtered to extract the ZnO NPs using filter paper, the precipitate was washed repeatedly with distilled water and ethanol to remove impurities. It was then placed in an oven to dry at 80 °C for 2 hrs. It was then calcinated at 400 °C for another 2 hrs and the calcined sample was grounded to obtain ZnO NPs powder.

Characterization of Zinc Oxide Nanoparticles

Scanning Electron Microscopy (SEM)

The powder was mounted on a metallic stub and an ultrathin coating was deposited by low vacuum sputter coating. This is done to prevent the accumulation of static electric fields at the specimen due to the electron irradiation during imaging and to improve contrast. The SEM was used to produce high resolution images of the sample surface.

X-Ray Diffraction

A thin film of the ZnO nanoparticles was made by dipping a glass plate in the solution and the film was used to carry out the X-ray studies. The diffraction pattern was recorded by Co–Kα1 radiation with a wavelength of 1.78 Å. The scanning was done in the region of 200 to 900 for 2θ at 0.020 /min and the time constant was 2 s. The crystal structure of the ZnO nanoparticles was confirmed from the X-ray diffraction.

Fourier Transform Infrared (FT-IR)

The FTIR Spectroscopy help to determine the functional groups present in the synthesized nano powders. The ZnO nanoparticles solution was filtered and the pellet was washed three times with 20 mL of de-ionized water to get rid of impurities that may be found in the Zinc oxide nanoparticles. The samples were dried and grinded with KBr pellets and analyzed on a Spectrum One, Perkin Elmer, USA model in the diffuse reflectance mode operating at a resolution of 2 cm^{-1} in the range of 400-4000 cm^{-1}.

IV. RESULTS AND DISCUSSIONS

The synthesis of the ZnO nanoparticles was done by adding Aloe Vera extract solution dropwise into the solution of zinc acetate with thorough mixing using a magnetic stirrer at 80 ^oC. The initial pH of the solution was measured to be pH 5 and was then adjusted to pH 8 using 0.2M sodium hydroxide to ensure total reduction of Zinc acetate to Zinc oxide nanoparticles [Sumon Das, 2018; Nagarajan and Kuppusamy, 2013]. The colour of the

mixture change to a slightly brownish solution after 4 hours as a result of production of a brown precipitate which indicated the formation of ZnO nanoparticles. The synthesized ZnO NPs was then filtered and washed with repeatedly with distilled water and ethanol to remove impurities. The ZnO NPs was then dried and calcined at 400 ^{o}C to obtain a white powder of ZnO NPs.

The morphology of the synthesized nanopartilces was examined using SEM. The SEM images of ZnO Nanoparticles at different magnification are shown in figure 1. The images showed a highly agglomerated semi spherical particles that are amorphous in nature.

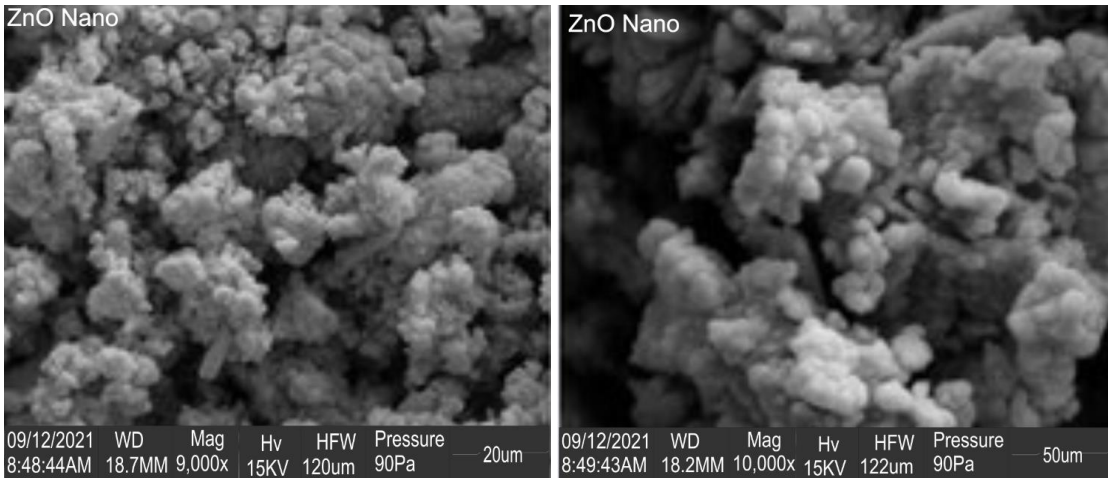

Figure 1: SEM images of ZnO Nanoparticles at 9,000 x and 10,000 x magnifications.

The X-ray diffraction pattern of the synthesized nanoparticles showed line broadening which was an indication that the particles were in nanoscale. The XRD pattern of the nanoparticles showed four strong peaks due to reflections from the (111), (220) (311) and (331) planes of the ZnO at angles (2θ) of 24.50 ^{o}, 30.40 ^{o} , 32.60 ^{o} and 45.20 ^{o} respectively for a hexagonal wurtzite crystal lattice (JCPDF file no. 00-036-1451), same as previously reported in other studies (Arakha, 2015).

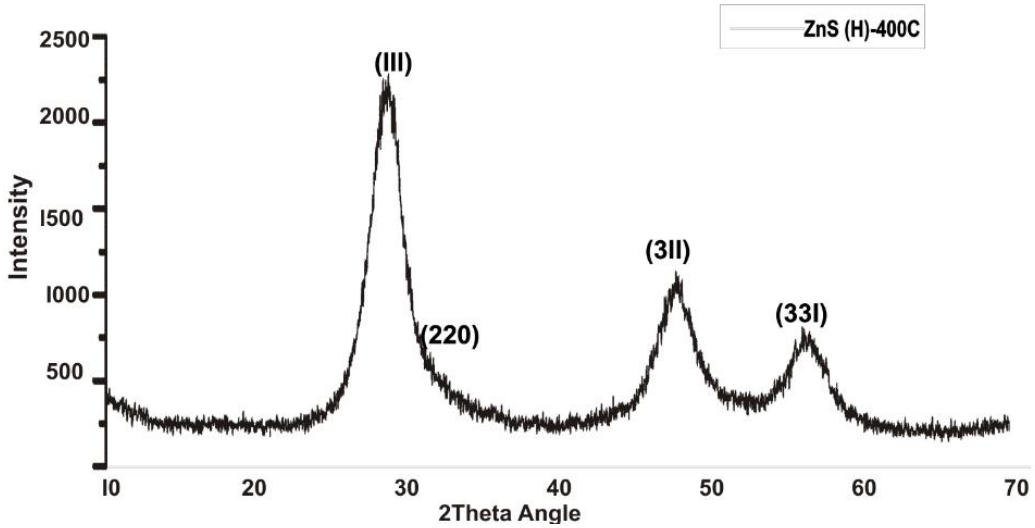

Figure 1.2: XRD of calcined ZnO Nanoparticles

Table 1 Showing the crystallographic parameters obtained from the X-ray diffraction

Peaks	2θ	FWHM	d - value	Miller index
1	24.5	1.024	1.35	111
2	30.4	0.031	2.250	220
3	32.6	1.121	2.023	311
4	45.2	1.131	2.213	331

Table 1. Shows the crystallographic parameters obtained from the X-ray diffraction. The peak with the highest intensity was used to calculate the particle size from its full width half maximum (FWHM) value. The particle size of the nanoparticles was determined to be 48.0 nm using Debye Scherer's equation.

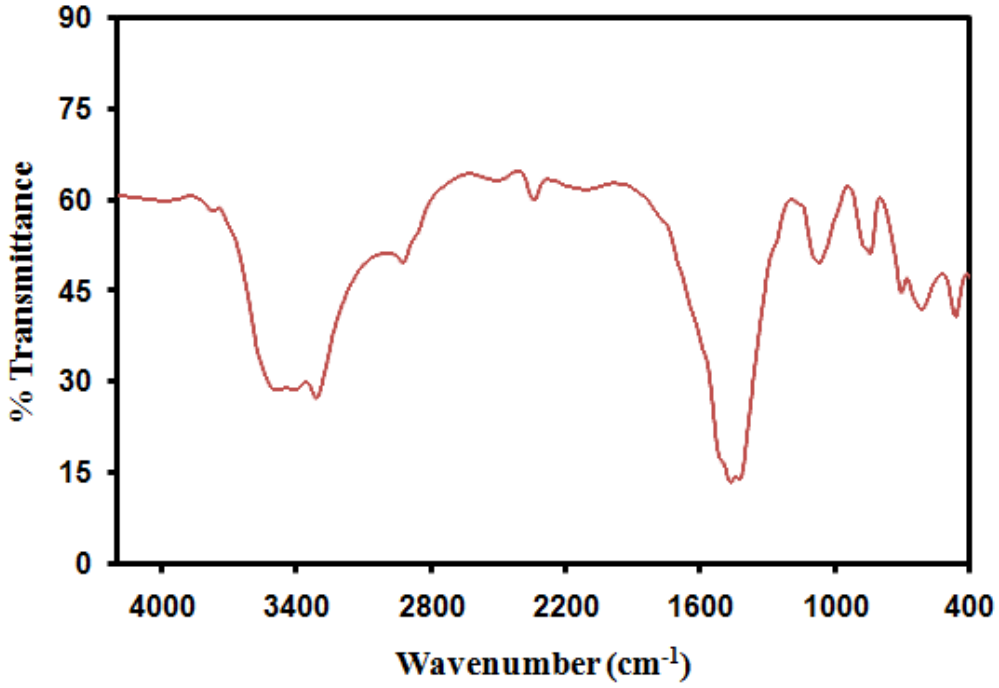

Figure 3.0 FTIR spectrum of the synthesized ZnO nanoparticles.

FTIR Spectroscopy was done to determine the presence of functional groups of the aqueous extract and the zinc oxide nanoparticles. Figure 3.0 shows the FTIR spectrum in the range of 4000-400 cm^{-1} of the synthesized ZnO nanoparticles. It was suggested that the formation of zinc oxide nanoparticles is due to the interaction of the phytochemicals such as phenol alkanes, and flavonoid groups present in the plant extract (Manase et al,2020). The Zinc oxide (ZnO) nanoparticles synthesised showed peak at 3275 cm^{-1} corresponding to O-H stretching of phenolic compounds, the alkene group present was attributed to the peak at 1624 cm^{-1} band. The band at 1313 cm^{-1} corresponds to C-N stretching bonds of the amines. The CO stretching of esters and carboxylic functional group matches the band between 1000 and 1300 cm^{-1}. The multiple sharp bands at 491 cm^{-1} and 435 cm^{-1} are attributed to the presence of Zinc and Oxygen bond stretching (Aziz and jassim,2018).The same range of vibrational bands have also been reported by other researchers (Lu,2019; Viswanathan,2020; Santhoshkumar,2017). It has also been reported that polysaccharide carbohydrate have strong binding ability with metals (e.g Zn) by forming an envelope on the surface to prevent its agglomeration during the synthesis (Kim 2019).

V. CONCLUSION

In this research, a simple method of synthesising of ZnO NPs using Aloe vera leaves extract was successfully achieved. The formation of the NPs was observed by a colour change to light brown precipitate which was confirmed using different characterisation techniques. The Nps were agglomerated but with high surface area. This showed that the NPs will find application in absorption studies and also in antimicrobial studies as the surface would provide sites for binding for microbes.

References

[1]. Amar, S. Resham, V. and Saple, D. G. (2008). Aloe vera: a short review. Indian journal of dermatology, 53(4): 163-166.
[2]. Arakha, M.; Saleem, M.; Mallick, B. C.; Jha, S. The effects of interfacial potential on antimicrobial propensity of ZnO nanoparticle. Sci. Rep. 2015, 5, 9578 DOI: 10.1038/srep09578
[3]. Aziz, W. J. and Jassim, H. A. (2018). A study of pH influence on Ag Nanoparticles size with antibacterial and antifungal activities using Green synthesis. Journal on world science news, 97(12): 139- 152.
[4]. Behboodi, S.; Baghbani-Arani, F.; Abdalan, S.; Sadat Shandiz, S. A. Green Engineered Biomolecule-Capped Silver Nanoparticles Fabricated from Cichorium intybus Extract: In Vitro Assessment on Apoptosis Properties Toward Human Breast Cancer (MCF-7) Cells. Biol. Trace Elem. Res. 2019, 187, 392−402.
[5]. Gengan, R.; Anand, K.; Phulukdaree, A.; Chuturgoon, A. A549 lung cell line activity of biosynthesized silver nanoparticles using Albizia adianthifolia leaf. Colloids Surf. B 2013, 105, 87−91.

[6]. Hamman J.H. Composition and applications of Aloe vera leaf gel. Molecules. 2008 Aug 8; 13(8):1599-616. doi: 10.3390/molecules13081599. PMID: 18794775; PMCID: PMC6245421.
[7]. Jinhuan, J. Jiang, P. And Jiye, C. (2018). The advancing of Zinc Oxide Nanoparticles for Biomedical application. Journal of Bioinorganic Chemistry and application, 4(2): 223-230.
[8]. Kim, W. J.; Soshnikova, V.; Markus, J.; Oh, K. H.; Anandapadmanaban, G.; Mathiyalagan, R.; Perez, Z. E. J.; Kim, Y. J.; Yang, D. C. Room temperature synthesis of germanium dioxide nanorods and their in vitro photocatalytic application. Optik 2019, 178, 664– 668, DOI: 10.1016/j.ijleo.2018.09.182
[9]. Laurent, S., Forge, D., Port, M., Roch, A., Robic, C., Vander Elst, L., & Muller, R. N. (2008). Magnetic iron oxide nanoparticles: synthesis, stabilization, vectorization, physicochemical characterizations, and biological applications. Chemical reviews, 108(6), 2064-2110.
[10]. Lu, J.; Batjikh, I.; Hurh, J.; Han, Y.; Ali, H.; Mathiyalagan, R.; Ling, C.; Ahn, J. C.; Yang, D. C. (2019) Photocatalytic degradation of methylene blue using biosynthesized zinc oxide nanoparticles from bark extract of Kalopanax septemlobus. Optik , 182, 980– 985, DOI: 10.1016/j.ijleo.2018.12.016.
[11]. Manasa, D. J. Chandrashekar, K. R. and Sana, S. (2020). Green synthesis of ZnO Nanoparticles from the leaf, stem, and Vitro grown callus of Mussaenda frondosa: characterization and their application. Journal of applied nanoscience, 10(8): 3057-3074.
[12]. Nagarajan S. and Kuppusamy,K.A "Extracellular synthesis of zinc oxide nanoparticle using seaweeds of gulf of Mannar, India," Journal of Nanobiotechnology, vol. 11, no. 1, pp. 1–11, 2013.
[13]. Rajan, R.; Chandran, K.; Harper, S. L.; Yun, S.-I.; Kalaichelvan, P. T. Plant extract synthesized silver nanoparticles: an ongoing source of novel biocompatible materials. Ind. Crops Prod. 2015, 70, 356−373.
[14]. Santhoshkumar.J, Kumar.S.V, Rajeshkumar S. Synthesis of zinc oxide nanoparticles using plant leaf extract against urinary tract infection pathogen. Resour. Technol., 3 (2017), pp. 459-465.
[15]. Sumon Das, T.C "A review on green synthesis of Ag NPs and ZnO NPs from different plants extract and their antibacterial activity against multi-drug resistant bacteria," Journal of Innovatinos in Pharmaceutical and Biological Sciences, vol. 5, no. 4, pp. 63–67, 2018.
[16]. Tanase, C.; Berta, L.; Coman, N. A.; Rosca, I.; Man, A.; Toma, F.; Mocan, A.; Jakab-Farkas, L.; Biro, D.; Mare, A. Investigation of In Vitro Antioxidant and Antibacterial Potential of Silver Nanoparticles Obtained by Biosynthesis Using Beech Bark Extract. Antioxidants 2019, 8, No. 459.
[17]. Viswanathan K., Kim I., Kasi.G, Sadeghi. K, Thanakkasaranee.S, J. Seo. Facile approach to enhance the antibacterial activity of ZnO nanoparticles. Adv. Appl. Ceram., 119 (2020), pp. 414-422.