Research Article

Green Synthesis of Zinc Oxide Nanoparticles Using Tea (*Camellia Sinesis*) and Datura (*Datura Stramonium*) Leaf Extract and Their Characterization

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Abstract

Nanoparticles are more effective and efficient than their larger sized molecules. The unique properties of nanoparticles are mainly due to their higher aspect ratio (surface area to volume ratio) and quantum effects. The chemical synthesis of nanoparticles causes release of toxic byproducts which contaminate the environment and lead to several health issues. Thus green synthesis or plant mediated synthesis of nanoparticles has emerged as alternate way to chemical synthesis. Green synthesis of nanoparticles is gaining importance due to their simplicity, eco-friendly nature, rapid rate of synthesis and less cost. The bio-active organic molecules present in the plant extract such as polyphenols, flavanoids, alkaloids, terpenes, tannins, steroids, saponins etc can reduce bulk molecules into its nanosized counterpart. More than that green synthesized nanoparticle found to be smaller in size and more stable than the chemically synthesized nanoparticles. The present study was conducted to green synthesis zinc oxide nanoparticles (ZnO NPs) from analytical grade reagent zinc nitrate (Zn $(NO_3)_2$) using tea (*Camellia sinesis*) and datura *(Datura stramonium)* leaf extract. The preliminary confirmation of tea and datura synthesized ZnO NPs were done by UV-spectroscopy where the absorbance peak of ZnO NPs dispersed in aqueous phase was obtained in UV wavelength range (355 and 368 nm, respectively). In particle size analyser, ZnO NPs synthesized with tea leaf extract recorded an average size as 54.5 nm and that of datura leaf extract was 62.8 nm. In scanning electron microcopy (SEM), shape of ZnO NPs synthesized with tea leaf extract was recorded as rod like with size range 45-75 nm and that of datura leaf extract was planar in shape like nanoflakes with size range 40-90 nm. Energy dispersive x-ray analysis (EDAX) of synthesized ZnO nanoparticles was done to determine its chemical composition and purity.

Keywords: Green synthesis, Characterization, Tea, Datura, Zinc oxide nanoparticles (ZnO NPs), EDAX, SEM, PSA

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Introduction

Nanotechnology is a novel and innovative technology which deals with the designing, development and application of devices, structures and particles in nanoscale (at atleast one dimension in nanoscale). Molecules are able to show some unique properties in their nano size range which can be used in different field of sciences including agriculture. Green nanotechnology is arising as a new branch of nanotechnology where plant mediated synthesis of nanoparticles had already got a wide attention due to its simplicity, eco-friendly nature, rapid rate of synthesis and less cost. The chemical synthesis followed by stabilization of synthesized zinc oxide nanoparticles (ZnO NPs) cause release of toxic by-products which are harmful to the ecosystem. Thus plant mediated synthesis has emerged as the best alternative to chemical synthesis.

Zinc is an essential nutrient and only one element that is represented in the all the six enzyme systems. Even though its requirement for crop plants is very low, it is considered as the fourth important yield limiting nutrient after NPK. There is a wide deficiency of zinc in Indian soil which is causing considerable reduction in yield. So there is need to supplement zinc nutrients to crop plants grown in Zn deficient areas. If the zinc is supplemented as its nanoformulation, its bioavailabilty and efficiency will be a more and it enhance the productivity. So to be economic, the ZnO NPs should be at affordable rate to the farmers. Thus green synthesis of ZnO NPs is getting its importance

Plants are the richest sources of bio-active organic molecules which include polyphenols, flavanoids, alkaloids, terpenes, tannins, steroids, saponins etc. These phyto-chemicals are non- nutritive in nature and produced in the plants as part of their defence mechanism to tolerate different kinds of stress [1]. Tea leaves are rich in the flavonol group of polyphenols known as catechins (approximately 30% of the dry leaf weight) and other polyphenols such as flavonoids and their glycosides, chlorogenic acid, gallic acid, coumarylquinic acid and theogallin [2]. Similarly datura is a weed plant grown under extreme stress condition like low availability moisture, high temperature, low nutrient status etc. such plant are rich in polyphenols and alkaloids [3]. Green synthesis of nanoparticles are favoured by the phenolic compounds present in the plant extract which exhibit higher antioxidant potential and reduces of metal ions to synthesis its nano sized particles particles. Further higher contents of proteins, lipids and amino acids help to stabilize the growth of nanoparticles and inhibit particle agglomeration [4]. The present study was to synthesis ZnO NPs from analytical grade zinc nitrate using the tea leaf extracts and datura extracts.

Material and Methods

Green synthesis of ZnO NPs

Zinc oxide nanoparticles (ZnO NPs) were synthesized from tea (*Camellia sinesis*) and datura (*Datura stramonium*) leaf extracts using zinc nitrate (Zn $(NO_3)_2$) as the precursor. The leaves were washed in running tap water to remove dirt and dust and dried under shade for 2 days. The leaves were then oven dried at 30 ºC for 6-8 days. After complete drying, the leaves were ground to powder using a mixer grinder and powdered leaf sample was stored separately in air tight polythene bags.

Ten gram powdered leaf sample was extracted with 100 ml distilled water (1:10) and boiled for 30-45 minutes with constant stirring and filtered to get 10 per cent extract. The leaf extracts were stored in a refrigerator. Ten ml of 10 per cent tea and datura leaf extract was boiled (in two separate beaker) on a hot water bath. When the leaf extract started boiling, one gram zinc nitrate was added and stirred constantly. The mixture was boiled till paste was obtained. The paste was then transferred to silica crucible and heated at high temperature of 400 ºC for two hours in a muffle furnace and cooled. Zinc oxide nanoparticles obtained as white powder were preserved in plastic vials for further characterization.

Table 1 Chemical composition of ZnO nanoparticles synthesized from tea and datura leaf extracts

Composition	ZnO NPs synthesized from tea leaf extract Wt %	ZnO NPs synthesized from datura leaf extract Wt %
C	44.36	49.67
ZnO	54.73	49.36
Na	0.12	-
Al	0.18	0.15
Si	0.13	0.16
S	0.21	0.29
K	0.27	0.37

Characterization of ZnO NPs

UV –spectroscopy

UV-spectrophotometer analysis was done for preliminary confirmation of green synthesized ZnO nanoparticles. Small amount of green synthesized ZnO NPs was dispersed in water by ultrasonication for 30 minutes. Dispersed sample was fed to UV- visible spectrophotometer and absorbtion peak of the sample was recorded with help of connected PC and the software SP-UV5.

Particle Size Analyzer (PSA)

Particle size analyzer was used for the proximate size determination of green synthesized ZnO NPs. Small amount of green synthesized ZnO NPs was dispersed in water using ultrasonication for 30 minutes. Dispersed sample was fed to particle size analyzer to determine the size distribution of nanoparticles in the dispersed solution. From the frequency distribution curve obtained against particle size, the average size of the particles was determined with standard deviation.

Scanning Electron Microscopy (SEM)

Scanning electron microscopy of green synthesized ZnO nanoparticles was done to determine the morphology (size and shape) of synthesized nanoparticles. SEM analysis was done using SEI-1130 machine (at TNAU, Coimbatore). Thin films of the sample were prepared on a coated copper grid by just placing a very small amount of the sample on the grid. Then, the film on the SEM grid was allowed to dry and the images of nanoparticles were taken to determine size and shape of nanoparticles.

Energy dispersive atomic x-ray analysis (EDAX)

EDAX analysis was done at TNAU, Coimbatore to determine the chemical composition of green synthesized nanoparticles. EDAX confirms the presence of zinc and oxygen, in the synthesized particles by analyzing their optical absorption

Results and Discussion

Green synthesis and characterization of ZnO nanoparticles

Green synthesized zinc oxide nanoparticles (ZnO NPs) were characterized through UV-spectroscopy, particle size analyzer (PSA) and scanning electron microscope (SEM) to determine their size and shape.

UV–spectroscopy

UV-spectrophotometer analysis was done for preliminary confirmation of green synthesized nanoparticles. Absorbance peak of green synthesized ZnO NPs obtained in UV-wavelength range (280-375 nm), which confirmed their size in nano range.

In UV-spectroscopy, zinc oxide nanoparticles synthesized from different plant extracts showed difference in their absorbance peaks (**Figures 1** and **2**). ZnO NPs synthesized using tea leaf extract exhibited absorbance peaks at 355 nm and that of datura was at 368 nm.

ZnO NPs synthesized from tea extract exhibited their absorbtion peak at the lower wavelength was supposed to have a smaller size than that synthesized from datura. When the size of bulk molecules get reduced to nano range, their absorbtion peak get shifted towards UV range from visible range. So nanoparticles exhibiting absorbtion peak at lower wavelength have smaller size than the particles exhibiting absorbtion peak at higher wavelength.

Absorbance peak of bulk molecules get shifted from higher wavelength to UV-wavelength range (280-375 nm) when they get reduced into nano-sized particles. Absorbance peak of ZnO NPs synthesized from tea and datura leaf extract were obtained in UV-wavelength range (at 355 nm and 368 nm, respectively) which confirmed their size in nano range (Figures 1 and 2). The ZnO NPs synthesized using leaf extract of *Hibiscus rosa-sinensis* had their absorption peak at UV wavelength of 358-375 nm and size ranged from 40 to 56 nm [5]. Green synthesized ZnO NPs found have a blue shifted absorption peak of ZnO NPs at 325 nm and their average size was recorded as 16 nm in XRD analaysis [4]. Similarly during the synthesis of ZnO NPs using *Pyrus pyrifolia* leaf extract, the absorption peak was found to be at 376 nm and in XRD analysis it had a wurtzite hexagonal structure with an average size of 22 nm [6]. During the synthesis of ZnO NPs with *Hibiscus subdariffa*, the absorbance peaks at 370 nm and the shape of nanoparticles was dumbbell with 30-50 nm as diameter [7].

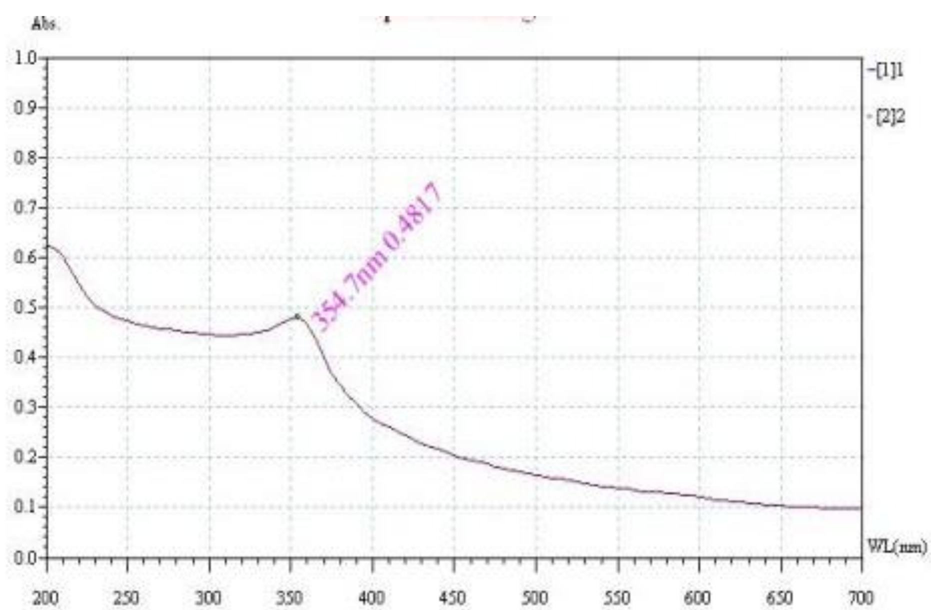

Figure 1 Absorbtion peak of ZnO NPs synthesized from tea leaf extract in UV-spectroscopy

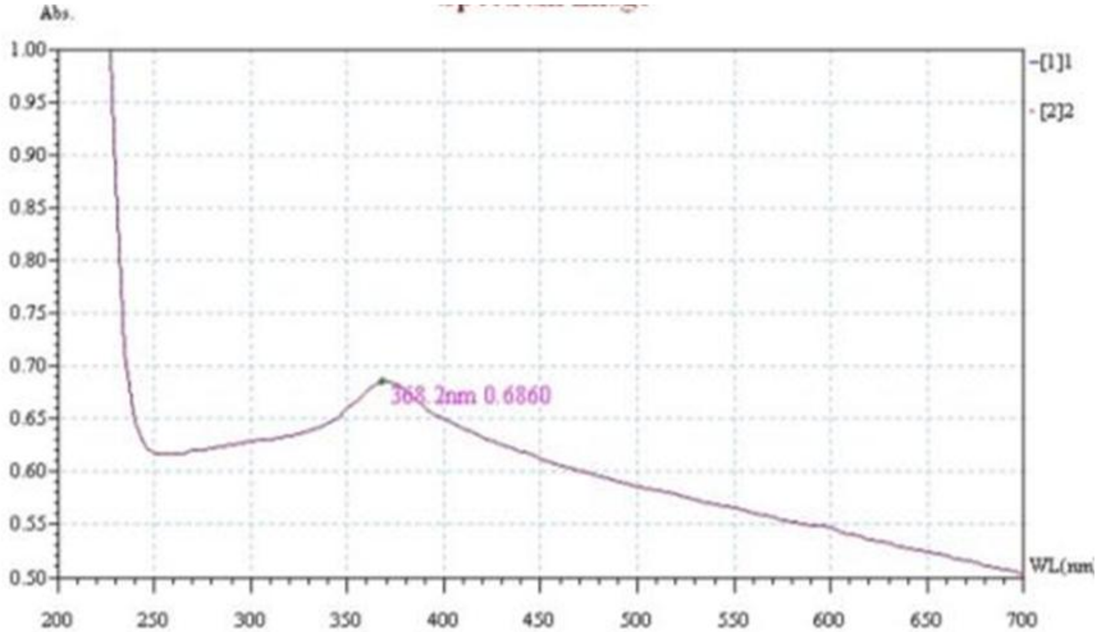

Figure 2 Absorbtion peak of ZnO NPs synthesized from datura leaf extract in UV- spectroscopy

Particle Size Analyzer (PSA)

Particle size analyzer was used for the proximate size determination of green synthesized ZnO NPs, because all the particles may not have single and same dimension. It determines the size distribution of nanoparticles in its dispersed solution and average size of nanoparticles was calculated from frequency distribution curve or cumulative distribution curve along with their standard deviation.

The analytical data of particle size analyzer clearly indicated that ZnO NPs obtained with tea leaf extract was smaller than that with datura leaf extract. The NPs obtained with tea and datura recorded an average size of 54.5 nm and 62.8 nm, respectively (**Figures 3** and **4**).

Particle size analyzer was used for the proximate size determination of synthesized ZnO NPs, because all the particles may not have single and same dimension. It determines the size distribution of nanoparticles in its dispersed solution and average size of nanoparticles was calculated from frequency distribution curve. In particle size analyzer radius of ZnO NPs synthesized from tea and datura leaf extract was recorded as 54.5 nm (Figure 3) and 62.8 nm (Figure 4), respectively (diameter-109 and125.6 nm, respectively).

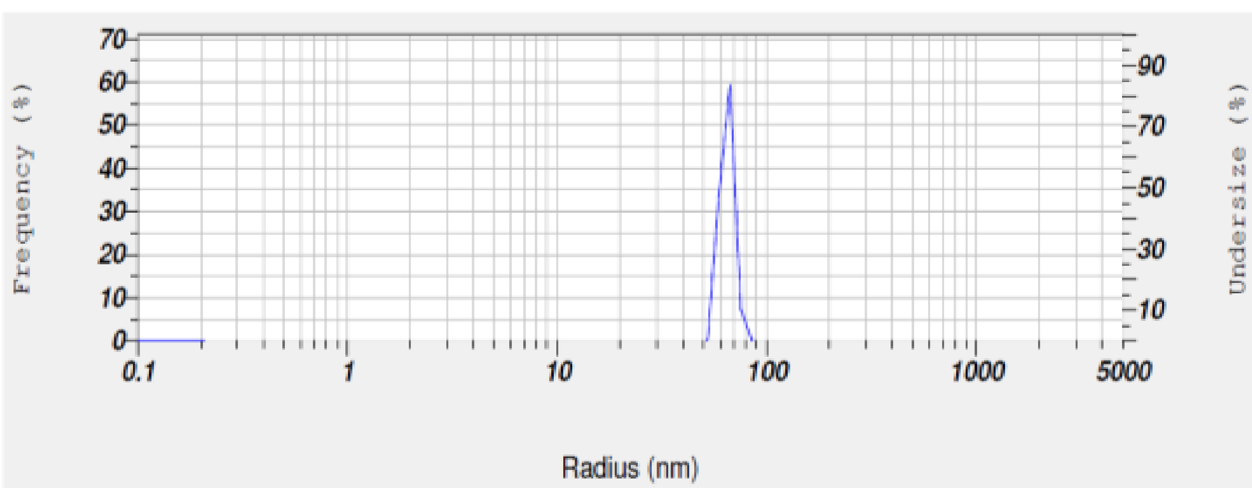

Figure 3 Average radius of ZnO NPs synthesized from tea leaf recorded in particle size analyser

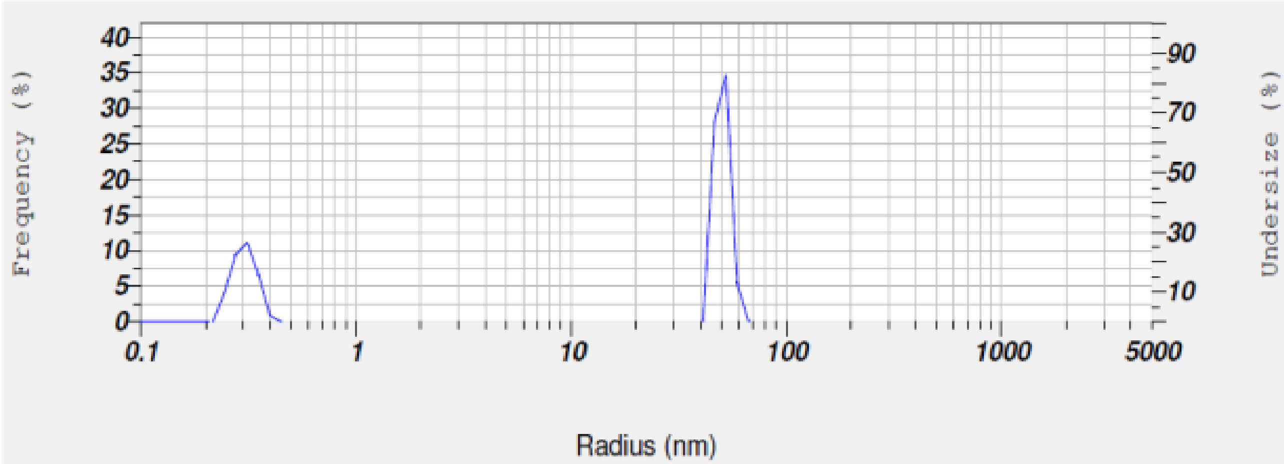

Figure 4 Average radius of ZnO NPs synthesized from datura leaf recorded in particle size analyser

Scanning Electron Microscope (SEM)

Scanning electron microscopy of green synthesized ZnO nanoparticles determined the morphology (size and shape) of synthesized nanoparticles. ZnO NPs synthesized from tea leaf extract were rod like in shape and size ranged from 45-75 nm (**Figure 5**). But that from datura leaf extract were planar in shape like nano-flakes and size ranged from 40-90 nm (**Figure 6**).

Scanning electron microscopy (SEM) of synthesized ZnO nanoparticles was done to determine its morphology (size and shape). In SEM, ZnO nanoparticles synthesized from tea leaves recorded rod like shape and size ranged from 45-75 nm (Figure 5) and that synthesized from datura leaf extract was planar in shape like nano flakes and size ranged from 40-90 nm. ZnO NPs synthesized using calotropis leaf extracts, when characterized with SEM was found to have a size range of 100 nm to 200 nm and FTIR (Fourier transform infrared) spectroscopy of synthesized NPs showed presence of hydroxyl, aromatic, amine and carbonate groupin its surface indicating that these functional group from leaf extracts were responsible for the synthesis of ZnO NPs [8]. Similarly, ZnO NPs synthesized using leaves of *Parthenium hysterophorous* characterized using SEM exhibited a size ranging from 16 to 108.5 nm and shape was spherical [9]. Neem mediated synthesis of ZnO NPs found to have flower as well as tubular morphology with size ranging from 25 to 200 nm [10]. SEM analysis ZnO NPs synthesized from Tulasi leaf extract revealed their shape as hexagonal and size ranged from 11 to 25 nm [11].

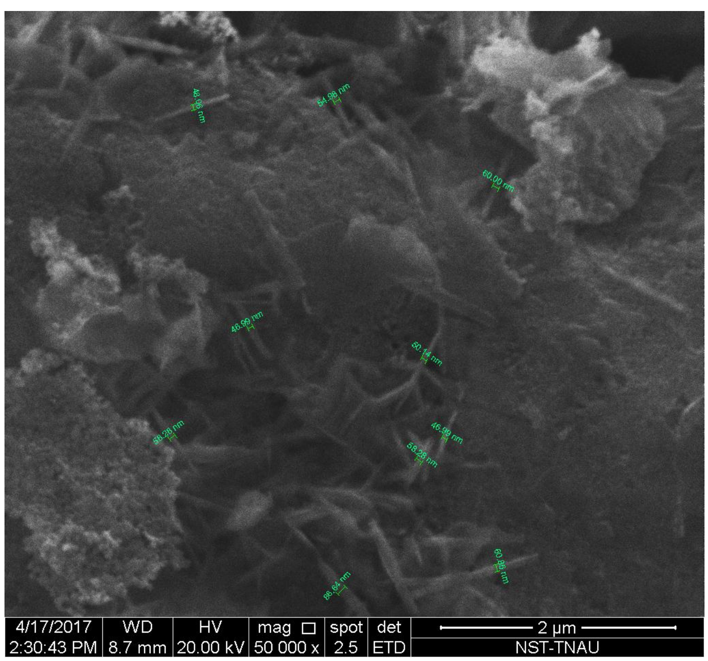

Figure 5 SEM image of ZnO NPs synthesized from tea leaf extract

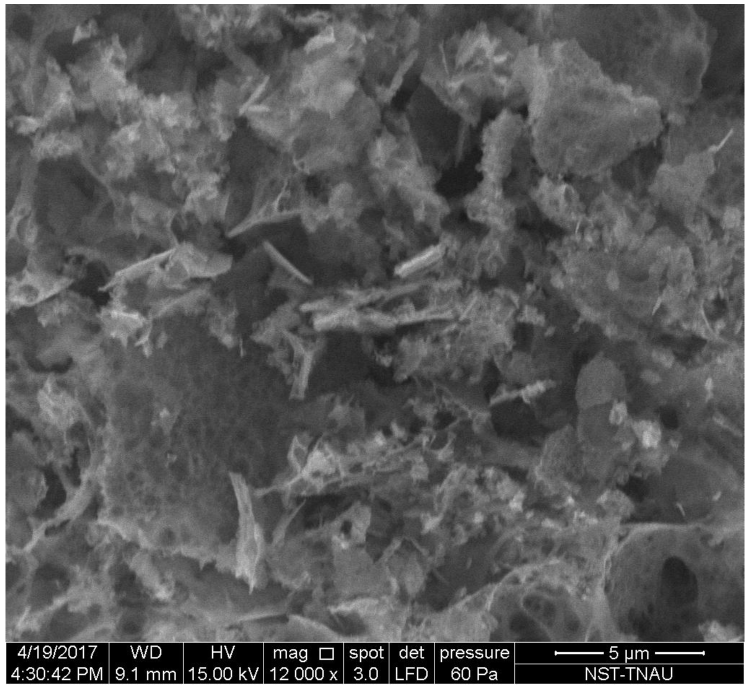

Figure 6 SEM image of ZnO NPs synthesized from datura leaf extract

Energy Dispersive Atomic X-ray Analysis (EDAX)

The elemental composition of green synthesized nanoparticles was determined in EDAX (**Figures 7** and **8**). ZnO NPs synthesized with tea leaf extract was found to have purity of 54.73 per cent and that of datura leaf extract was 49.36 percent. While rest of sample weight was occupied with carbon and other foreign elements (trace in amount) present in the leaf extracts. Tea and datura synthesized ZnO NPs had a carbon content of 44.36 and 49.67 percent respectively. The high carbon content in the synthesized ZnO nanoparticles provides stability to the particle in their aqueous solution. Due to the hydrophobic nature of carbon coated ZnO nanoparticles, it gets dispersed well in the aqueous formulation.

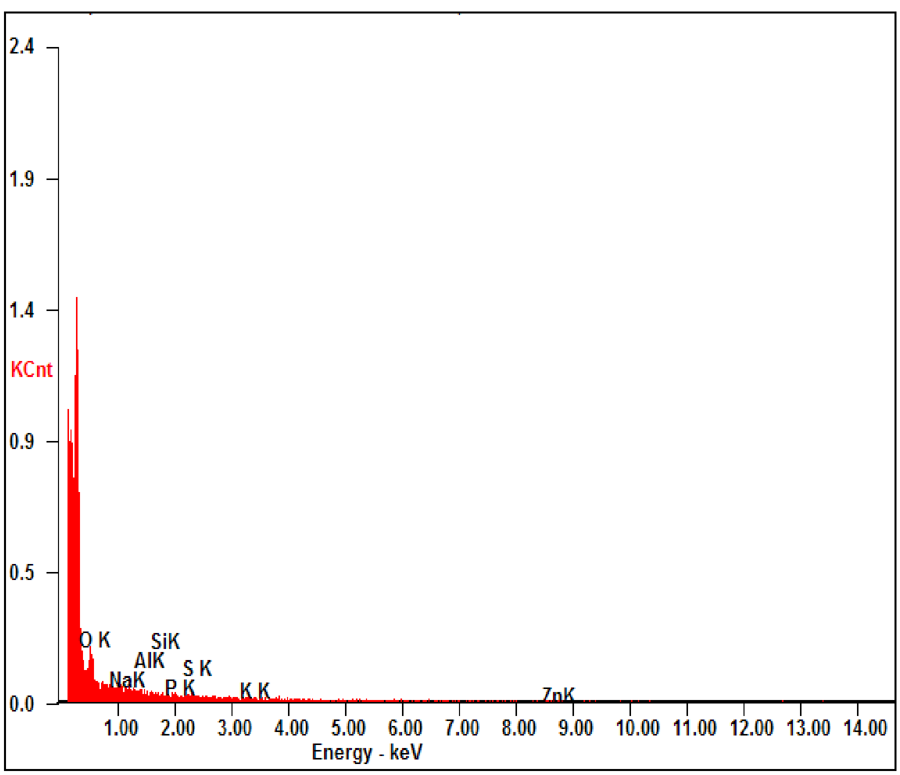

Figure 7 EDAX analysis of ZnO NPs synthesized from tea leaf extract

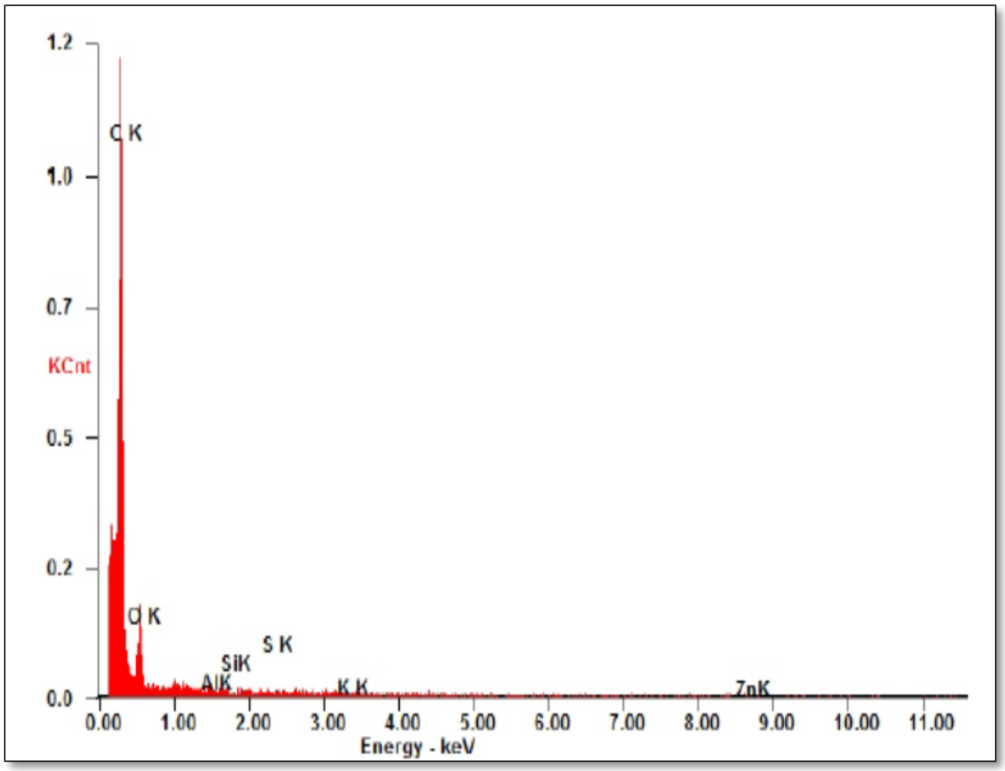

Figure 8 EDAX analysis of ZnO NPs synthesized from datura leaf extract

The elemental composition of green synthesized nanoparticles was determined in EDAX (Table 1). It was found that ZnO NPs synthesized with tea leaf extract has 54.73 and 44.36 percent ZnO and carbon, respectively (Figure 7), while that from datura leaf extract found to have 49.36 and 49.67 percent ZnO and carbon, respectively (Figure 8). While rest of the sample weight was because of other elemental impurities from leaf extracts. The presence of carbon and other elemental impurities in small amount and concluded that the stability of green synthesized nanoparticles could be due to organic molecules. Dispersed aqueous solution of green synthesized nanoparticles showed better stability due to the presence of organic molecules. Hydrophobic nature of organic molecules prevents agglomeration of nanoparticles and causes its effective dispersion and stabilization in aqueous solution [7].

Conclusion

ZnO nanoparticles can be green synthesized from analytical grade reagent zinc nitrate using the leaf extract of different plants. Here for the present study, tea and datura leaf extract were used. The two plants are known for their medicinal values which are contributed by the active principle and biomolecules present in their extract. The bio-molecules present in the leaf extract act as reducing, capping and stabilizing agent and convert bulk molecules into its nano- sized particles. The chemical synthesis and stabilization of ZnO NPs cause release of toxic by-product which is harmful to the ecosystem. Also during chemical synthesis some toxic chemicals get adsorbed on the surface of ZnO NPs which restrict its medical applications. Some chemical synthesis methods require high temperature and pressure which make the synthesis process expensive. Presently, plant mediated synthesis or green synthesis has emerged as the best alternative to chemical synthesis of nanoparticles due to their simplicity, cheapness and eco-friendly nature. These green synthesized nanoparticles were found to be more stable than the chemically synthesized nanoparticles due its high carbon content which make it hydrophobic in nature. Thus these particles get dispersed well aqueous solution and remain stable for a longer period and are suitable for preparing aqueous formulation. Foliar application ZnO NPs at low concentration (250-750 ppm) is found to be effective increasing dry matter and yield maize plants [12]. Green synthesized ZnO NPs can be used as an efficient zinc source to supplement crop plants grown in Zn deficient areas.

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References

[1] D. K. Tiwari, N. D. Schubert, L. M. V. Cendejas, J. Villegas, L. C. Montoya and S. E. B. Garcia. Interfacing carbon nanotubes (CNT) with plants: enhancement of growth, water and ionic nutrient uptake in maize (Zea mays L.) and implications for nanoagriculture. Applied Nanoscience, 2013, 4: 577-591.

[2] V. Shah, and I. Belozerova. Influence of metal nanoparticles on the soil microbial community and germination of lettuce seeds. Water, Air and Soil Pollution, 2009, 197: 143–148.

[3] S. O. Ajiboso, M. T. Yakubu and A. T. Oladiji. Chemical profile of aqueous extract of Calotropis procera leaf. World Journal of Pharmaceutical Research., 2015, 4(6), 362-369

[4] S. R. Senthilkumar and T. Sivakumar. Green tea (Camellia sinensis) mediated synthesis of zinc oxide (ZnO) nanoparticles and studies on their antimicrobial activities. International Journal of Pharmaceutical Science, 2014, 6(6): 461-467.

[5] M. J. Divya, C. Sowmia, K. Joona and K. P. Dhanya, K. P., Synthesis of zinc oxide nanoparticle from Hibiscus rosa-sinensis leaf extract and investigation of its antimicrobial activity. Research Journal of Pharmaceutical, Biological Chemical Sciences, 2013, 4(2): 1137-1142.

[6] C. Parthiban and N. Sundaramurthy. Biosynthesis, characterization of ZnO nanoparticles by using Pyrus pyrifolia leaf extract and their photocatalytic activity. International Journal of Innovative Research in Science, Engineering and Technology, 2015, 4(10): 9710-9718.

[7] N. Bala, S. Saha, M. Chakraborty, M. Maiti, S. Das, R. Basub and P. Nandy. Green synthesis of zinc oxide nanoparticles using Hibiscus subdariffa leaf extract: effect of temperature on synthesis, anti-bacterial activity and anti-diabetic activity. RSC Advances, 2015, 5: 4993-5003.

[8] J. Poovizhi and B. Krishnaveni. Synthesis, characterization and antimicrobial activity of zinc oxide nanoparticles synthesized from Calotropis procera. International Journal of Pharmaceutical Sciences and Drug Research, 2015, 7(5): 425-431.

[9] K. S. Sindhura, T. N. V. K.V. Prasad, P. Selvam and O. M. Hussain. Synthesis, characterization and evaluation of effect of phytogenic zinc nanoparticles on soil exo-enzymes. Applied Nanoscience, 2013, 4: 819–827.

[10] D. Gnanasangeetha and S. D. Thambavani. Facile and eco-friendly method for the synthesis of zinc oxide nanoparticles using Azadirachta and Emblica. International Journal of Pharmaceutical Sciences and Research, 2014, 5(7): 2866-2873.

[11] S. Raut, P. V. Thorat and R. Thakre. Green synthesis of zinc oxide (ZnO) nanoparticles using Ocimum tenuiflorum leaves. International Journal of Science and Research, 2013, 5: 1225-1228.

[12] S. P. Chaitra. Studies on nano zinc oxide dynamics and response of maize to foliar spray of nano formulations in a Vertisol under controlled condition. M. Sc. Thesis, 2015, Univ. Agric. Sci., Dharwad, Karnataka (India).

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