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Green Synthesis of Zinc Oxide: Spectral and Thermal Study

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ABSTRACT

In this presented research work, synthesis, production and manipulation of nano size particles are done with malt, meat and yeast. Different eco-friendly methods are used to synthesis ZnO nanoparticles, to avoid its toxicity. Green chemistry is one of the most efficient ways to produce these nanoparticles. Different plants, flowers, yeast, fungus, bacteria and algae are used to prepare nanoparticles of ZnO. ZnO nanoparticles are fabricated by using three different samples like malt extract, meat extract and yeast extract through green chemistry route on nanometer scale. Different physical and chemical methods are used characterize the designed nanosize particles. SEM, TGA, UV-Vis and XRD were confirmed the fabrication of ZnO nanoparticles on supramolecular scale. The resultant synthesis nanoparticles are used in the field of biomedical applications.

Keywords: ZnO; Nanoparticle; Green Chemistry; Thermal Stability

Introduction

In perspective field of science in which the different type of matter on nano scale (atomic or molecular level) is called nanotechnology [1-4]. Nanotechnology finds its wide applications in broad fields of living and non-living science as diverse including engineering, electrochemistry, semiconductor physics, catalysis, medical devices, molecular biology, organic chemistry, energy storage, textile industry, cleaning agents, micro fabrication and molecular engineering [5-8]. The compounds of zinc oxide are inorganic in nature, which has the formula ZnO. ZnO powder has white color that cannot be solved in water. These nano particles exhibit non-corrosive, antifungal, antibacterial, and show different properties after filtering from UV-Vis spectroscopy [9]. Zinc is placed in periodic table of elements at a position of Period 4 in block D and Oxygen is placed at a position in Period 2 with block p elements.

Oxozinc, permanent white, ketozinc, oxydatum, zinci oxicum are the alternate elements of zinc oxide nanoparticles. Many biochemical and physical methods have been developed and are being used for the fabrication of metal-oxide nano particles in a short period on a large scale [10,11]. Beneficial optoelectronic properties exhibited by ZnO nanoparticles are in the range including high exciton binding energy [12], semiconducting, UV spectrum and direct band gap. The ZnO nps have wide applications in nanoscience, field of medicines especially in the area of cancer treatment [12,13]. Environment friendly, fast and a simple technique to synthesize zinc oxide nanoparticles through biofuels of different fruits and extracts [14]. Porous zinc oxide nanostructures with small size particles distribution can be prepared by using green eco-friendly method [15]. The hydrothermal method at low temperature in which nanostructures of zinc dioxide [ZnO] were fabricated then decomposed into a desired material [3]. A clean and ecofriendly method to prepare zinc oxide nanoparticles is Schiff Zn (II) is a complex material was obtained by the addition of a compound alanine to another compound 5-sulphonate- salicyaldehyde acting as a compound of carbonyl obtained by the proper mixing of zinc (II) acetate with Schiff ligand. Zn (II) was decomposed to give zinc oxide nanoparticles [16].

In this presented research work is the novel route of synthesis of ZnO nanoparticles by green chemistry method using bioextract namely Meat, Yeast, and Malt. The spectral and thermal investigations are presented in this designed research work for numerous biomedical applications.

Experimental

Materials

To synthesis the ZnO nanoparticles (ZnO nps), Zinc Nitrate ($Zn(NO)_3$, 99% Purity) and Sodium Hydroxide (NaOH) were used as starting materials and were provided by Sigma Aldrich. For green synthesis purpose Meat extract, Yeast extract, and Malt extract were received from NEXUS WISE, Malaysia in pure grinded and powder form. Deionized water was collected from our own laboratory in University of Lahore, Lahore (Figure 1).

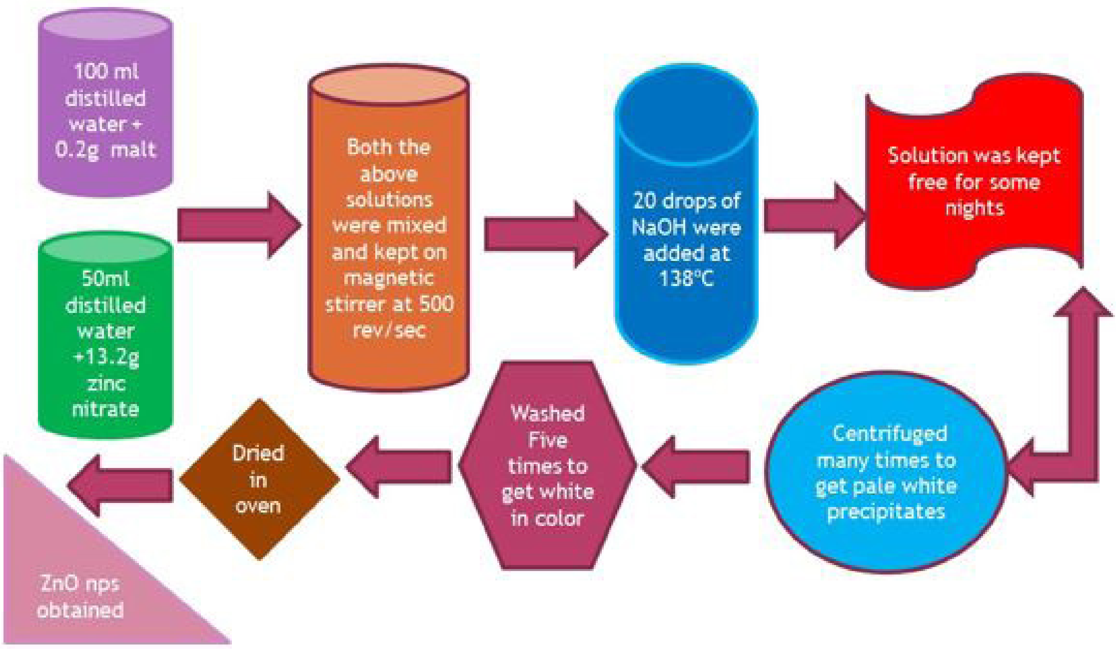

Figure 1: Schematic diagram for the fabrication of ZnO nps by extract

Methods

Synthesis of ZnO via malt extract

ZnO nps were prepared through green chemistry method via using three different extracts namely Malt, Yeast, and Meat extract. First of all, 0.1M solution of Zinc Nitrate was prepared on hotplate with magnetic stirring using 50ml deionized water (DIW). Secondly, 0.2g extract was dissolve in 100ml water with vigorous magnetic stirring. After complete dissolving of salt and extract in separate solution, both are mixed in the large beaker with continuous stirring. Thirdly, the homogeneous mixture of salt and extract for two hours two hours. Next, drop by drop addition of NaOH in the prepared solution till the formation of pale white precipitates. Then, allow to set the precipitate in the bottom of the beaker with overnight stay and the supernatant was discarded. 4500rpm for 10 minutes in thrice times to obtained the pale white solid product. Washing was followed to get the white powder of ZnO nps. Dried in oven and crushed the powder to store in dry and air tight box. Three samples of ZnO were prepared by the variation of three different extracts, namely M-ZnO (Malt based), Y-ZnO (Yeast based), and B-ZnO (Meat based).

Characterization

Spectral, optical, and thermal properties are investigated of the designed ZnO nps via green chemistry method. Scanning Electron Microscope (SEM, JEOL JSM-40, Japan) is used to check the morphology of the synthesis ZnO nps. Optical properties from UV absorption spectra were analyzed by UV-Vis spectrophotometer (UV2450, Shimadzu). Phase purity and confirmation was done by X-Ray Diffractometer (XRD, STOE, Japan). Perkin-Almer Thermogravimetric Analysis is performed to check the thermal stability of designed nanoparticles.

Results and Discussion

Scanning Electron Microscope (SEM)

Scanning electron micrograph is used to analyze the morphology of extract based ZnO nano particles. SEM micrographs of synthesized ZnO with green-chemistry [extract] are shown in the Figure 2a,b and c

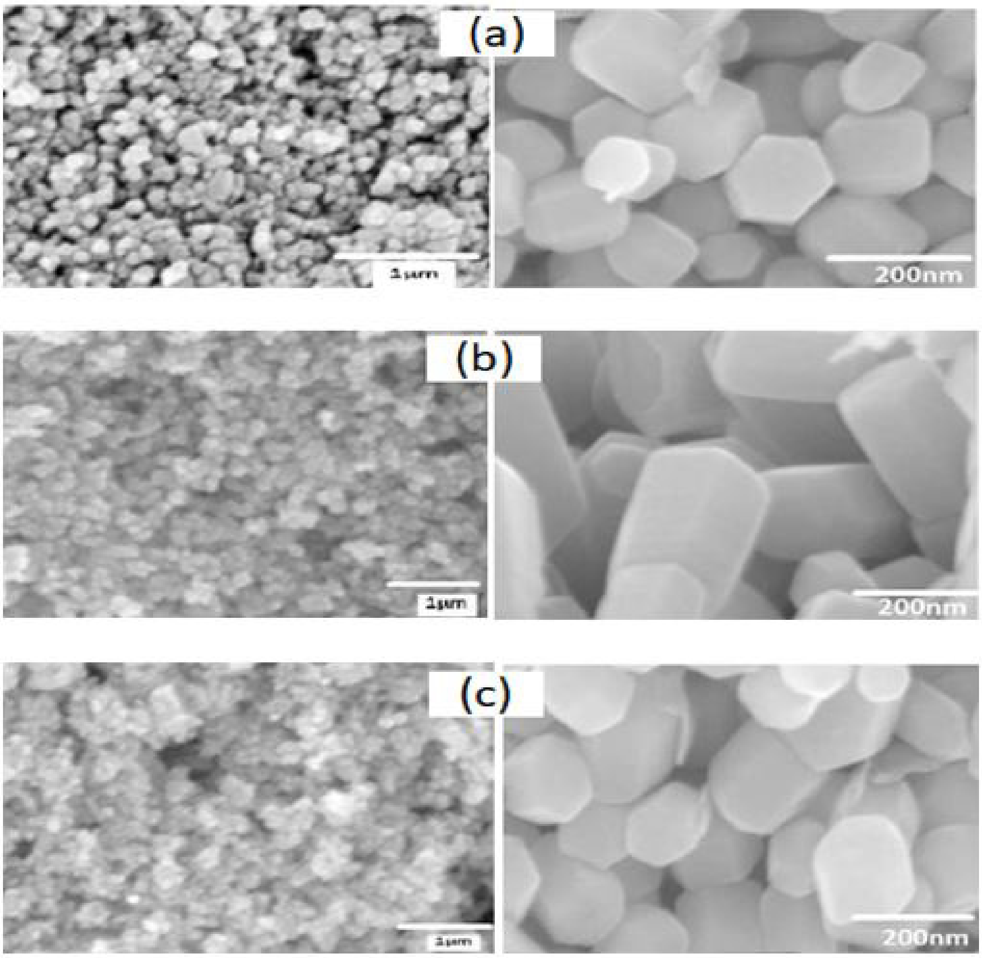

Figure 2: SEM images of ZnO nps prepared by green chemistry **(a)** Malt Extract; **(b)** Yeast Extract; **(c)** Meat Extract

Nano structure morphologies of synthesized ZnO nps are shown with the average size range of [40nm- 60nm]. It is cleared from the microstructures that the spherical morphology is formed. Surface morphology of green synthesized ZnO nps are aggregated to each other. SEM images show that the shape of the resultant nps changed from spherical to rod like. These findings are the close agreement of previously reported [17].

UV-VIS Spectroscopy Study

UV-Vis spectroscopy is performed to study size and shape of the biosynthesized ZnO nps. The strong absorption peak was observed at 358nm as clearly observable in the U-VIS absorbance spectra in Figure 3.

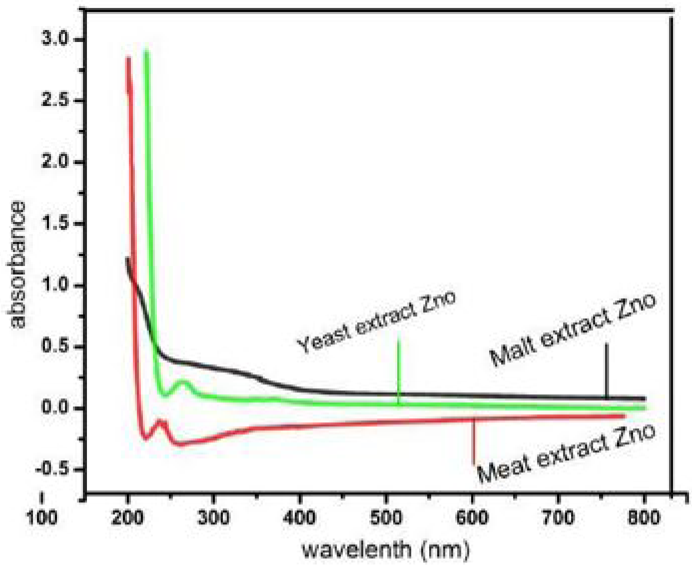

Figure 3: A schematic diagram of UV-VIS spectroscopy

The reason behind this absorption peak is the surface plasmon absorption on ZnO nps. This surface Plasmon absorption on nps of metal oxide is due to the absorption of collective oscillation of electron in conduction band. It experienced electromagnetic radiations. The sharpness in the peak elucidates the formation of uniform size of ZnO nps. Green fluorescence in alcohol under the UV lamp narrates the synthesis of ZnO nps. The observed absorption ranges from 252 to 350nm is belong to the diameter of nps with increasing wavelength indicate the co-existence of large size nps. The UV-VIS absorption spectra of synthesized nps cleared that the absorption band in blue shift is due to the quantum confinement of the excitation. The optical phenomenon presents the design nps have quantum size effect. Characteristic features of used extracts are fair indication of resultant ZnO nps in this behavior [13].

XRD (X-Ray diffraction)

X-ray diffraction technique is used to confine the green-synthesized ZnO nps. Figure 4 demonstrates the XRD pattern by using copper K-α radiation and intensity data is in the 2θ range of 20 °C-80 °C with scan rate of 0.05. The average size of the synthesized nanosized ZnO was calculated with Debye sherrer formula at diffraction intensity of [101] peak. XRD analysis narrates the wurzite phase and all diffracted peaks match with the reported JCPDS (36-1451) data. The definite broadening of line in the diffraction peaks is the clear indication of nm range bio-synthesized ZnO nps. XRD study greatly supports the SEM analysis. The influence ofthe used extract is clearly observed in the XRD pattern of designed ZnO nps, which clear this trend [18].

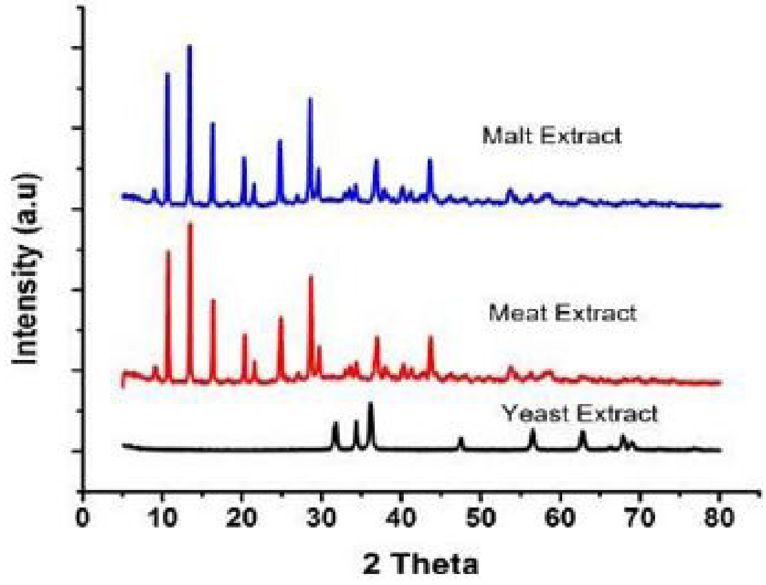

Figure 4: A schematic diagram of XRD

Thermogravimetric Analysis (TGA)

Thermogravimetric analysis [40] is performed to study the thermal degradation behavior of green synthesized ZnO nps from room temperature to 700 °C with 10 °C rise per minute in oxygen environment. Thermograms of ZnO are depicted in Figure 5.

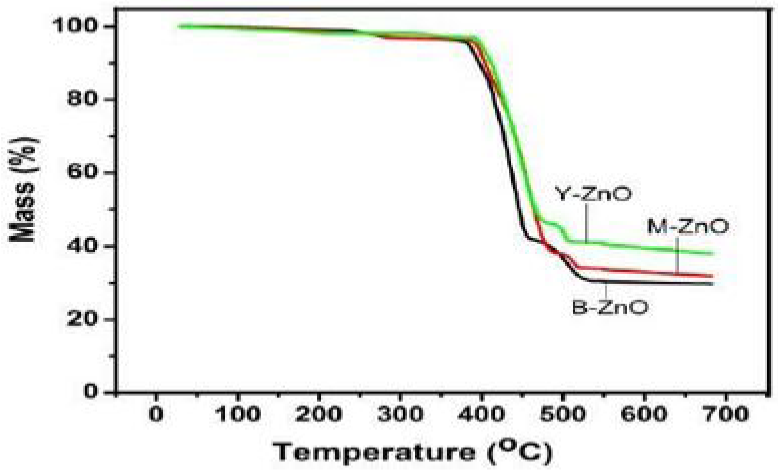

Figure 5: Thermogram of ZnO nps with various extracts

The prepared ZnO with different extracts follow the different trend of degradation. Y-ZnO [yeast based], > M-ZnO [malt based], > B-ZnO [meat based] is more thermally stable at 450 °C, 500 °C, 600 °C and 700 °C. TGA thermo grams follow the three steps ion mass loss. 3-4% mass loss is due to the vaporization of moisture and low molecular weight gasses. The second step is at high temperature [400 °C] owing to the thermal decomposition of organic group present in the ZnO specimen in biosynthesis process.

Moreover, the mass loss in the third step is very small. Range of temperature is due to the pyrolysis of oxide groups in the synthesis of ZnO nps. No reaction is observed at temperature above 600 °C. It is obvious from the thermo grams that the residual weight % at the end of the degradation is best with yeast extract synthesize ZnO nps. The reason behind this phenomenon is the strong molecular binding of yeast, which there by increased the residual weight percent [19].

Conclusion

In this study, ZnO nanoparticles are fabricated by green chemistry method with three different extract namely, malt extract, meat extract and yeast extract. SEM, TGA, UV and XRD characteristics were confirmed the fabrication of ZnO nanoparticles on supramolecular scale. Thermogravimetric (TGA) analysis confirmed the degradation behavior of ZnO nanoparticles from room temperature to 700 ^{o}C with 10 ^{o}C rise per minute in oxygen environment. Degradation behavior occurs in three steps each step involves 3-4% ion mass loss. The ZnO nanoparticles prepared by yeast samples find their best results because of their low degradation in molecular weight. SEM results confirmed the size range of ZnO nanoparticles from 40nm to 60nm with change in morphology from spherical to rod like shape. XRD results confirmed the wurtzite structure of ZnO nanoparticles. The average size of ZnO nanoparticles was calculated with Debye sherrer formula at diffraction intensity of peak. Diffraction peaks observation at specific angles 12^{o},18^{o},25^{o} were confirmed ZnO nanoparticles with wurtzite structures. UV-Vis spectroscopy was used to confirm the absorption range of radiations of ZnO nps. Range of absorption observed from 252nm-350nm belong to the diameter of ZnO nanoparticles with increasing wavelength indicate co-existence of large size nps. The absorption ranging from 252nm-350nm in UV-vis spectrograph was in agreement with its white color with the band gap of 3.25-3.27ev. All the reported results are in agreement with the previously available experimental and theoretical studies for many biomedical applications.

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