

## Synthesis of ZnO Nanoparticles Using Green Tea Powder Extract

S. THAKUR<sup>1</sup>, S. RIALACH<sup>1</sup>, S. SWAIN<sup>1</sup>, M. SWAIN<sup>2</sup>, D. M. MISHRA<sup>2</sup> and G. SAHOO<sup>1†</sup>

<sup>1</sup>*Department of Physics and Astronomical Science, Central University of Himachal Pradesh, Dharamshala, HP, 176206*

<sup>2</sup>*Department of Physics, Indian Institute of Technology, Jodhpur, Raj, 342030*

<sup>†</sup>*E mail gourishankar.sahoo@gmail.com*

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**Abstract:** The increasing demand for cost-effective, eco-friendly synthesis of nanoparticles has stimulated researchers to investigate the utilization of plant extracts in the synthesis process. This results in non-toxic by-products. No critical condition of temperature and pressure is required in this process. Synthesis of Zinc oxide (ZnO) nanoparticles using green tea powder extract is reported in this communication. Green tea contains polyphenols like catechins, phenolic acid around 30%, and these compounds with anti-oxidant potential, acts as reducing agent on the metal oxides. Moreover, significant presence of proteins (15%), lipids (7%) and amino acids (4%) stabilizes the growth of ZnO nanoparticles and inhibits particle agglomeration. The structural and morphological investigation of said nanoparticles is carried out using X-ray diffraction, Field Emission Scanning Electron Microscopy, UV-Visible spectroscopy. The average particle size of ZnO nanoparticles synthesized using green tea powder extract in sol-gel method is found to be having 30.73 nm.

Key words; nanoparticles, catechins, phenolic acid, sol-gel method

### 1. Introduction

Environmentally friendly synthesis of nanoparticles known as green synthesis has attracted considerable attention in recent past due to its nontoxic nature, which have applications in medicine, agriculture and cosmetics [1-4]. Green synthesis is also cost effective, facile and generates harmless by-products. Zinc oxide (ZnO) is a novel nanomaterial and has many usages in the above

applications. It can be used in nano-medicine [5-7] due to its tunable size, morphology and electronic structure. It is also used as nano-fertilizer in agriculture and can enhance crop yield of rice, wheat and finger millets [8 - 10]. As the intake of nanoparticle together with drugs or foods has increased in humans, animals and plants it is paramount that the synthesis is clean and green and free of hazardous chemicals. Therefore, there is an urgent need to optimize the green synthesis of nanoparticles in general and ZnO in particular.

In a typical chemical synthesis process of ZnO nanoparticles, zinc acetate, zinc nitrate or zinc acetate dehydrate is used as the starting precursor, which is reduced in presence of reducing agent dissolved in alcoholic solvents like ethanol or methanol. For example, ZnO nanoparticle of 30 nm sizes have been synthesized using citric acid as complexing agent [11]. In sol-gel method, zinc acetate dehydrates and methanol solutions are mixed with ammonia to raise the pH between 9 – 11 and ZnO nanoparticles of average size of 22 nm can be synthesized, which can be dried and used as nano powder form [12]. Similarly, zinc acetate dehydrate mixed in ethanol and sodium hydroxide (NaOH) can produce nanoparticles of mean size of 80 nm [13]. Marinho et al used zinc acetate in Urea solution with potassium hydroxide (KOH) and obtained ZnO nanoparticle of 25 nm in hydrothermal method [14].

There are several other chemical methods to obtain ZnO nanoparticles with controlled morphology and sizes for various applications, namely, co-precipitation, chemical vapour deposition, microwave combustion etc [13]. All of these well-established synthesis methods use harmful chemicals such as ammonia, urea, citric acid, sodium and potassium hydroxide along with toxic by-products. Ammonia is a skin irritant and affects eye sight, pungent odour, whereas urea targets the kidney and liver in the body, if consumed directly or indirectly [13, 15, 16]. Therefore, in the recent past several efforts have been made to replace these chemicals with green tea extracts. Green tea extract mainly contains polyphenols including flavonoids. The phenolic compounds like catechins, phenolic acid, amino acids, caffeine have very good anti-oxidant potential. Hence, green tea extracts can be used as very good reducing agent for metal ions and can replace conventional industrial chemicals [18-22].

## **2. Materials and Methods**

In the first synthesis step, the reducing agent was extracted from green tea leaves. Green Tea (*Camellia Sinensis*) extract (CSE) was prepared by adding 20 g of dried and thoroughly grinded Kangra Green Tea leaves in 100 mL of deionized water. This solution was stirred and boiled at 70 °C for 30 minutes on a hot plate, followed by cooling at room temperature. Subsequently, the solution was centrifuged at 5000 rpm for 10 minutes. The supernatant fluid was then collected and stored in a refrigerator at 5 °C for further experiments.

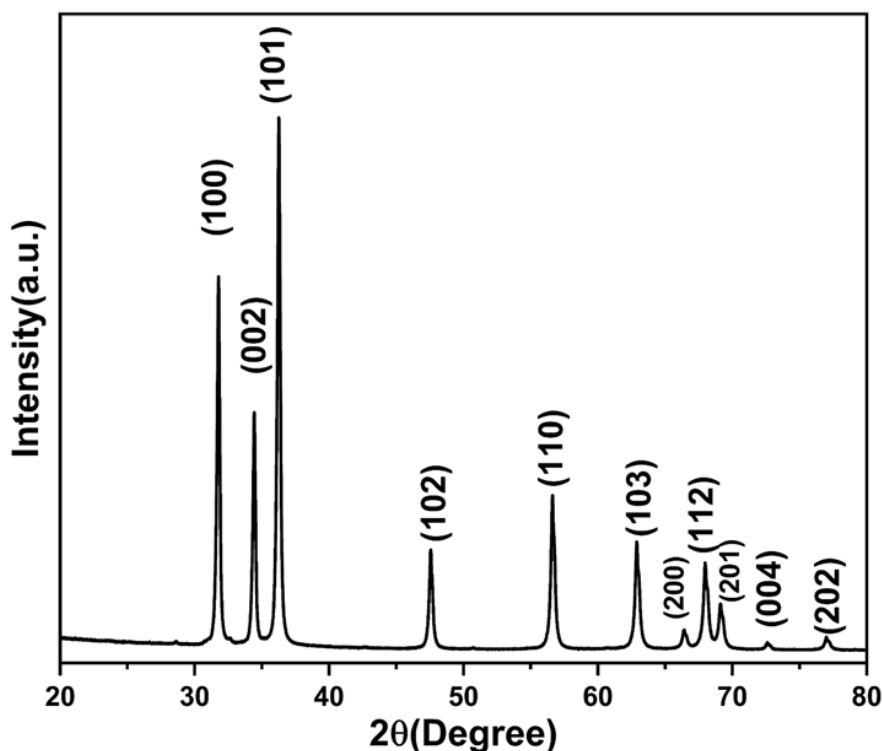
In the second step, zinc nitrate ( $\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ ) (of Merck chemicals) and tea leaf extract were mixed in a ratio of 1:3. 2 g of  $\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$  was dissolved in 10 ml of deionized water and stirred for 1 hour to obtain a homogeneous solution. Thereafter, 30 ml of CSE was added to the zinc nitrate solution and stirred for another 1 hour. The beaker was then moved to a sand bath maintained at 75 °C. Stirring was continued for 12 hours to obtain a brown color precipitate. The final product was heat treated at 400 °C in air for 4 hours in a muffle furnace to obtain a white powder of zinc oxide nanoparticles.

After the synthesis the structural and optical characterizations of the nanoparticles were carried out. The crystal structure was obtained from X-ray powder diffraction (XRD) pattern with a X'Pert-PRO advanced diffractometer using Cu ( $K\alpha$ ) radiation (wavelength: 1.5406 Å) at 40 kV and 40 mA at room temperature in the range of  $2\theta$  from 20 to 80°. The morphology was revealed by ZEISS field-emission scanning electron microscope (FE-SEM). The absorption spectra were recorded with a Metrohm (Analytical Jena-Secord 205) double beam instrument at room-temperature within a wavelength range of 200-800 nm.

## **3. Results and Discussion**

### **3.1 XRD**

Figure 1 shows the XRD pattern of the synthesized powder, which shows the well crystalline state of the nanoparticles.



**Fig. 1.** XRD pattern of the ZnO nano-particles

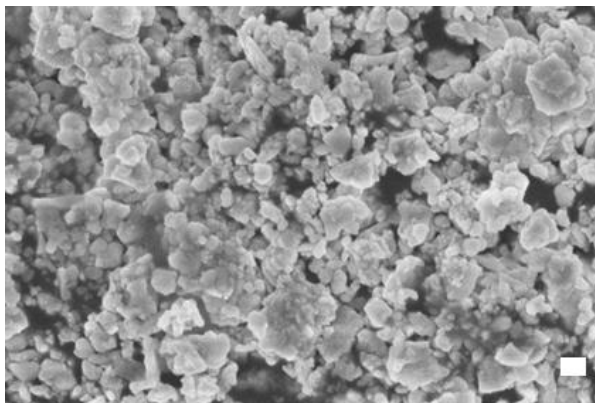
The crystal structure analysis of ZnO nanoparticles was carried out and we can observe the presence of diffraction peaks at  $2\theta$  values of 31.78, 34.42, 36.26, 47.54, 56.61, 62.86, 66.39, 67.96, 69.10, 72.56 and 76.98, that can be indexed to the (110), (002), (101), (102), (2-10), (103), (200), (2-12), (201), (004) and (202) crystal planes, respectively (COD database code 9011662). The Primitive structure belongs to the hexagonal  $P6_3mc$  space-group with lattice angles  $\alpha=\beta=90^\circ$  and  $\gamma=120^\circ$ . The XRD results indicate that pure and polycrystalline ZnO nanoparticles can be obtained using CSE as a green synthesis process. The average crystallite size was calculated using the Scherrer equation:

$$D = \frac{k\lambda}{\beta \cos \theta}, \quad (1)$$

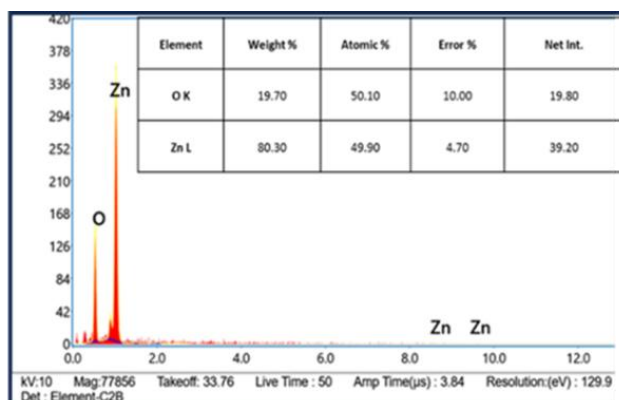
in which  $\beta$  is the full width at half-maximum intensity of the diffraction peak in radians,  $k$  is a dimensionless shape constant (here 0.9),  $\lambda$  is the X-ray wavelength (0.154 nm),  $D$  is the crystallite size and  $\theta$  is the Bragg's angle. The average crystallite size for ZnO particles was found to be 30.73 nm using the two most

intense peaks, indexed (101) and (100). Interplanar spacing and (h k l) data were used to calculate the lattice parameters, which were deduced to be  $a=b=3.2494 \text{ \AA}$  and  $c=5.2038 \text{ \AA}$ .

### 3.2 FE-SEM & EDS



**Fig. 2:** (a) FE-SEM image

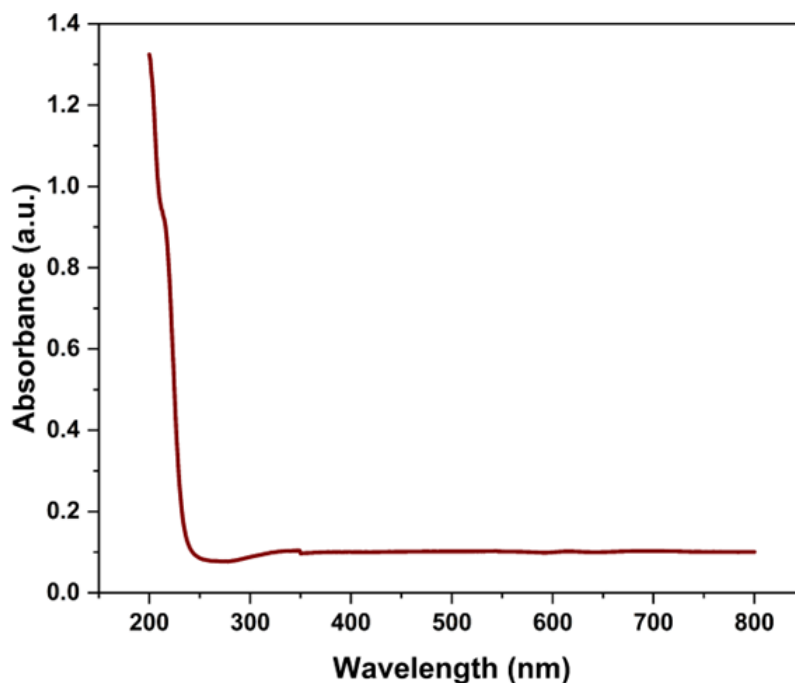


**Fig. 2:** (b) EDS of ZnO nano-particle. The scale bar is 200 nm

Figure 2 (a) shows the FE-SEM image of ZnO nanoparticles sample. The synthesized ZnO nanoparticles have average sizes of 30 nm, which corroborates the XRD analysis. Many particles have an irregular morphology due to dense agglomerations in the powder form. The energy dispersive X-ray spectroscopy (EDS) is shown in Fig 2 (b). It confirms the presence of Zn and O in the sample

with 1:1 stoichiometric ratio expected for ZnO. The atomic percentage ratios are tabulated in the table (inset of Fig 2 (b)).

### 3.3 UV-VIS Spectroscopy



**Fig. 3.** UV- visible spectra of ZnO nanoparticle

The absorption measurement (Figure 3) shows that ZnO is highly transparent in visible range. The band gap of bulk ZnO is 3.23 eV ( $\lambda = 383.85$  nm) and it shows variation in nanoparticle form (range from 3.1 – 3.4 eV), which is confirmed in the absorbance measurement.

### 4. Conclusion

ZnO nanoparticles with average particle size 30.73 nm were synthesized using green tea leaf extract having an irregular morphology. The structural analysis showed pure single phase ZnO with hexagonal crystal structure with wide electronic band gap close to the bulk value. The tea leaf extract contains phenolic compounds, which play an important role as reducing agent and stabilizing agent as well. This facilitates formation of stable ZnO nanoparticles in DI water, which does not contain any toxic chemicals typically obtained in

conventional synthesis methods. Therefore, the synthesized nanoparticles have great application potential in nano-medicine, nano-fertilizer and environmentally friendly products.

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