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RESEARCH PAPER

Structural, Optical, Thermal and Photocatalytic Properties of ZnO Nanoparticles of Betel Leave by Using Green Synthesis Method

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ABSTRACT

In this present study reports the green synthesis of zinc oxide nanoparticles using Betel leaf extracts and zinc acetate. The functionalization of ZnO particles through Betel leaf extract mediated bio reduction of ZnO was investigated through X-ray diffraction, Field emission scanning electron microscopy, photoluminescence, thermal gravimetric-differential thermal analysis, hexagonal shaped ZnO-nanoparticles with size about 50 nm were synthesized and characterized using X-ray diffraction analysis. The diameter of the nanoparticles in the range of 50 nm was found from scanning electron microscopy study. Photo luminescence study reveals the blue emission at 463nm respectively. hermal gravimetric-differential thermal analysis show that the observed at 480°C, indicating that no decomposition occurs above this temperature. The photocatalytic degradation of methylene blue dye was examined using ZnO nanoparticles under solar as well as ultra violet light irradiation of the MB dye. The method stands out primarily due to the fact that it is eco-friendly and shuts down the demerits of conventional physical and chemical methods. These particles are anticipated to have extensive applications in various industries.

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INTRODUCTION

ZnO, also known as Zincite, is a wide and direct band-gap semiconductor (~3.7 eV) at room temperature [1,2]. Nanoparticles exhibit atom-like behavior due to high surface energy resulting from high and large specific surface area, high fraction of surface atoms and wide gap between valence and conduction band when divided to near atomic size [3,4,5]. This has several favorable properties like high electron mobility, good transparency, wide band gap for semi-conductivity, high room-temperature luminescence [6].These properties are used in applications of nanogenerators [7], gas sensors [8], luminescent material [9], optoelectronics [10], Biosensors [11],solar cells [12], varistors [13], photodectors [14], photo catalyst[15], antibacterial materials[16], and catalyst[17].physical and chemical methods utilize less time for synthesizing large quantities of nanoparticles, they require toxic chemicals as capping agents to maintain stability, thus leading to toxicity in the environment. Keeping this in consideration, green nanotechnology using plants is emerging as an eco-friendly alternative, as plant extract mediatedbiosynthesis of nanoparticles is cost-effective [18]. ZnO has been synthesized in a plethora of shapes with a nano size controlled manner in view of targeted applications in electronic, photonic and spintronics devices. A rich variety of physical (vapor-phase process)

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and chemical (solution phase) methodologies were used to synthesize undoped or doped ZnO [19]. The present study reports for the first time synthesis and characterization of ZnO-NPs using Betel leaves extract and zinc acetate [20].

EXPERIMENTAL

Synthesis of ZnO-NPs

Betel leaves were collected from the plants in and around Pulivendula area, Andhra Pradesh, India. ZnO Acetate was gathered from Sigma Aldrich chemicals in India. The Betel fresh leaves were washed thrice with distilled water to remove dust. After that the betel leaves were chopped to collect the extract from this leaves. Water added to the extract in the (1:3) ratio and boiled at 80^{0}C for 45 min. After this solution is cooled at room temperature at 6hrs. Zinc Acetate was taken (0.1M) (1gm of Zinc acetate was dissolved in 50ml distilled water) to add the water. The extract solutions were stirred on the magnetic stirrer and added the prepared Zinc Acetate solution drop wise. The stirring process is continued for 11-12hrs. After stirring final solution were placed in room temperature at one day. Next day the solution was put into the Muffle furnace at 7hrs. From the furnace the solid type zinc Oxide is available these solid ZnO is grinded with mortar pestle. The prepared powder of ZnO nanoparticles is annealed at 400^{o}C.

RESULTS AND DISCUSSION

The purity, crystallinity, average particle size of ZnO Nanoparticles was confirmed by X-ray diffraction technique. The XRD pattern of

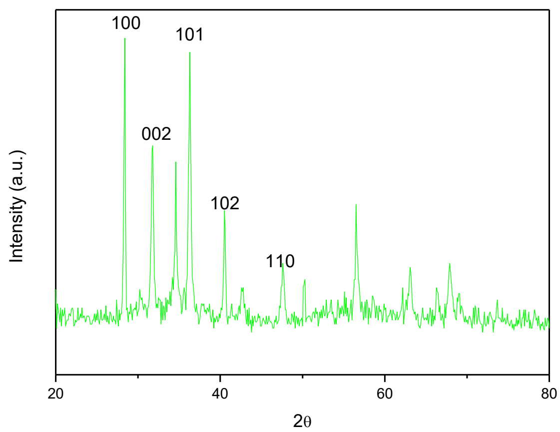


Fig. 1. XRD pattern of ZnO NPs

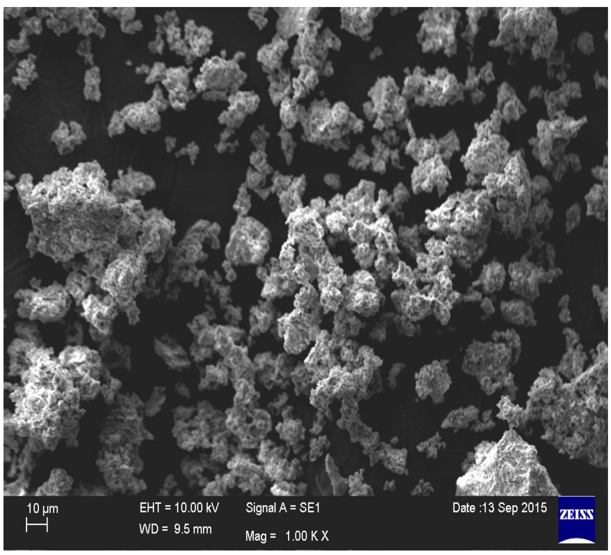
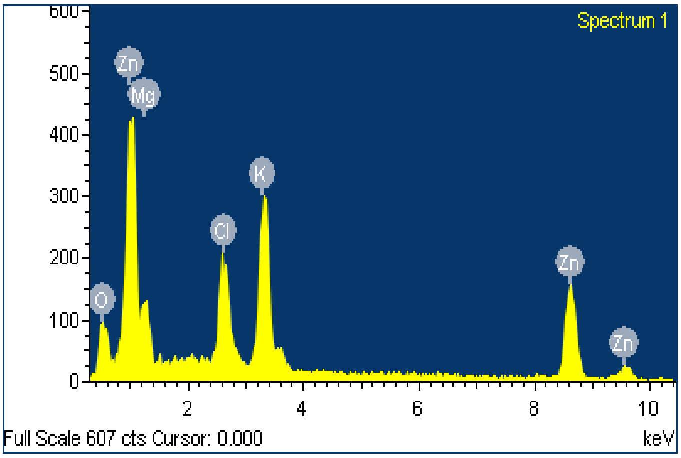


Fig. 2 .SEM image of ZnO NPs



Element	Weight%	Atomic%
O K	18.72	39.88
Mg K	9.12	12.78
Cl K	9.09	8.74
K K	16.36	14.26
Zn K	46.71	24.35
Totals	100.00	

Fig. 3. EDX spectrum of ZnO NPs

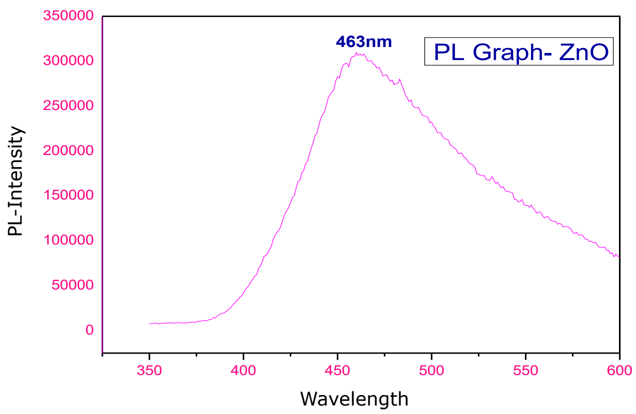


Fig. 4. Photoluminescence spectra of ZnO NPs

culminated ZnO Nanoparticles is recorded in the range of 400°C. The sharp peak indicates the purity and crystallinity of Nanoparticles. The XRD Peaks are consistent with the JCPDS data cord 79-207 hexagonal phase and primitive geometry of ZnO Nanoparticles. The detected peaks corresponded with those of hexagonal phase Zincite were found at the lattice plains of (100),(002),(101),(102),(110),(103),(112), and (202) in the 2 Theta value: 31.77°, 34.45°, 36.25°, 47.53°, 56.54°, 62.83°, 67.89°, 76.87°, respectively.

$$D = \frac{0.9\lambda}{\beta \mathrm{Cos}\ \theta}$$

Where D is the average crystallite size in Å, K is the shape factor (0.9), k is the wavelength of X-ray (1.5406 Å) CuK radiation, the Bragg angle, and b is the corrected line broadening of the NPs. The crystalline size of the most intense plane (101) was 50 nm, determined by Debye-Scherer's equation. Nano sized value of ZnO suggests that Betel leaves extract can be employed as the hydrolytic and precipitating agent for the formation of ZnO Nanoparticles. Broadening of XRD patterns can be attributed to size of the nanoparticles, while strong and narrow peaks indicate that the product has good crystallinity [21, 22, 23].

The SEM micro graphs of as prepared ZnO Nano

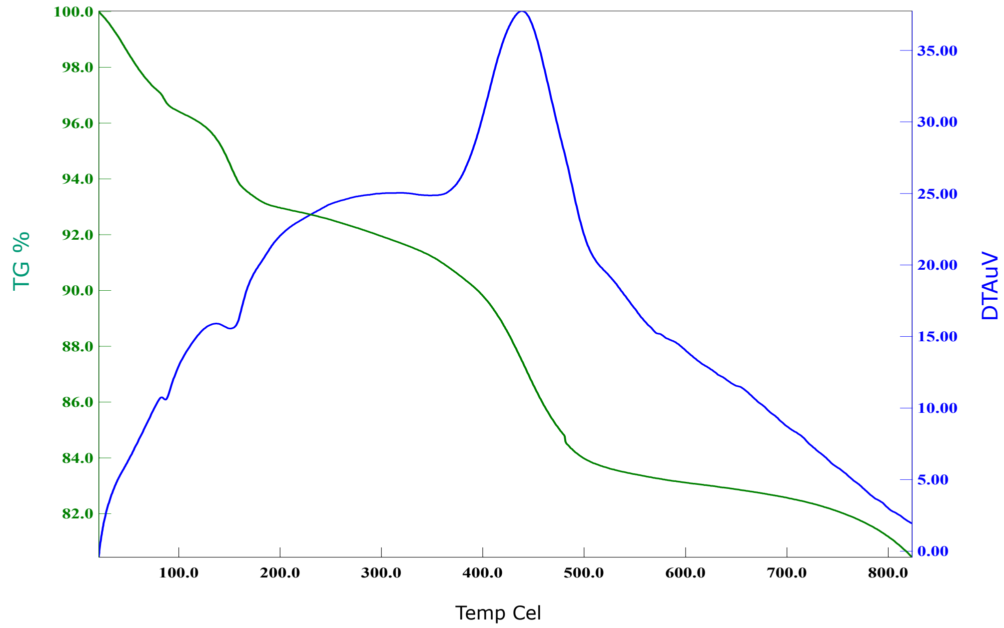


Fig .5 TG–DTA curves of the ZnO NPs

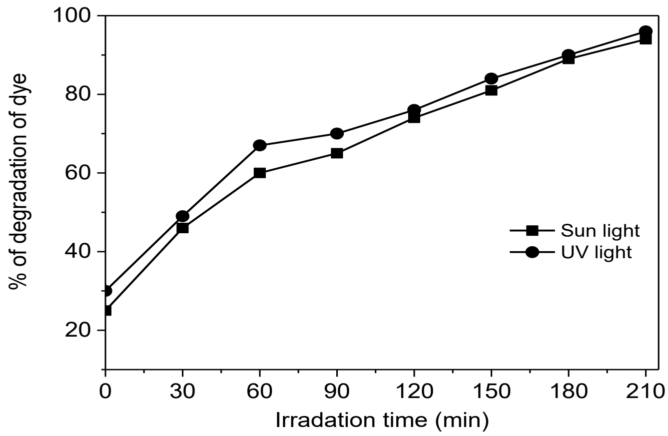


Fig. 6 Effect of different light source on photo catalytic degradation

particles it is observed that almost spherical in nature further, the particles are agglomerated to form sponge like bunch of particles. The agglomeration could be induced by densification resulting in the narrow space between particles. When gas is escaping with high pressure, pores are formed with the simultaneous formation of small particles.

EDX of the sample indicated the presence of Zinc and Oxygen at stoichiometric ratio Mg, Cl, K elements in the EDX Spectra shows the presence of stabilizing agents which wereoriginated from plant extract. In Fig. 1 indicating bioactive compounds were absorbed of Betel leaves of ZnO nanoparticles at 400^0C .

At the room temperature PL spectra of ZnO Nano crystalline particles was measured at an excitation wavelength of 321nm and excitation wavelength shows a strong super blue band cantered at 462nm. The PL of ZnO nanostructures has been studied extensively, for their potential use as optical material. The super blue emission possibly due surface defects in the Nano crystalline particles in case of ZnO nanomaterial reported by other researches. The blue emission corresponds to the singly ionized ionized oxygen vacancy in ZnO. This emission results from the recombination of a photo-generated hole with the single ionized charge state of the specific defect[27, 28].

Thermo Gravimetric Analysis (TGA) and Deferential Thermal Analysis (DTA) were performed on thermal analysis with dry air as carrier gas. The TG curve shows a major weight loss step from 400 up to 500^{0}C with no further weight loss observed up to 750^{0}C. The TGA curve has the small weight loss between765 to 850^{0}C. Between 765 to 850^{0}C TG curve indicates the formation of Nano crystalline ZnO as decomposition product.

The DTA curve shows that exothermic effect was observed between 400 to 500^{0}C with maximum at about 450^{0}C, indicating that the thermal events can be associate with the burn out of organic species involved in the precursor powder[24,25]. No further weight loss and no thermal effect were observed at 480^{0}C, indicating that no decomposition occurs above this temperature [26, 27].

Fig. 6 shows the effect of different light source on photocatalytic degradation of methylene blue. Two different light sources are used namely Sun light and UV light. From the figure, it is cleared that photocatalytic degradation of the dye for 210 min was more in UV light (96%) than in Sun light (90%). This is due to the fact that UV light has higher intensity (lower wavelength or higher energy), so that light can easily penetrate and result in the formation of more number of radicals, which increases the rate of photocatalytic degradation of methylene blue dye.

CONCLUSION

Green synthesis of hexagonal (wurtzite) shaped ZnO-NPs of about 50 nm has been achieved using leaf extract of Betel leaves. Thus bringing into light yet another use of the plant, besides its usual utilities. The SEM analysis reveals that the particles are agglomerated to form sponge like bunch of particles and EDX show that the presence of Zinc and Oxygen at stoichiometric ratio's. At the room temperature PL spectra of ZnO Nano crystalline particles was measured at an excitation wavelength of 321nm and emission wavelength shows a strong super blue band cantered at 462nm. TG-DTA show that the observed at 480^{0}C, indicating that no decomposition occurs above this temperature .The method stands out primarily due to the fact that it is eco-friendly and shuts down the demerits of conventional physical and chemical methods. These particles are anticipated to have extensive applications in various industries.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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