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Green Synthesis, characterization and antibacterial activity of CuO nano particle

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Abstract

A green low temperature combustion route is proposed for the synthesis of CuO nano particles, using Copper nitrate powder and *Nigella sativa* (Kalonji) *seed* extract as the starting materials. The formation of CuO Nps was characterized by PXRD, SEM, UV-Visible etc. The PXRD Pattern reveals that as-synthesized CuO Nps of monoclinic phase and Crystallite structure. The scanning electron microscopy (SEM) images reveal the morphology of the nanoparticles are spherical in shape. CuO Nps show significant antibacterial activity against both gram +ve and Gram-ve bacterial strains using agar well diffusion method. The present method brings out a promising green, simple, low cost and low temperature way to prepare multifunctional CuO nanomaterials.

1. Introduction

Copper oxide nanostructures have attracted significant attention because of their wide range of applications such as high-Tc superconductors [1],sensors [2,3], catalytic [4], optical [5], electrical [6],giant magnet resistance materials gas sensors, solar energy transformation and preparation of organic–inorganic nanostructure composites [7].CuO is a p-type semiconductor with the band gap~1.7ev.It can be used as an anti-microbial , anti-biotic and anti-fungal agent when incorporated in coatings, plastics ,textiles, etc. [8]. Copper and copper-based compounds were efficient biocidal proper-ties, which were generally used in pesticidal formulations and several health related applications. Different methods were available to prepare CuO Nps namely sol–gel technique [9], Sonochemical, alkoxide based route, electrochemical methods, precipitation-pyrolysis, microwave irradiations, solid-state reaction method, thermal decomposition of precursor [10], etc. Solution combustion synthesis (SCS) is one of the simple and easiest methods for synthesis of metal oxide *Nigella sativa* (Kalonji) *seed* extract as a fuel.

2. Experimental

2.1. Synthesis

CuO nanoparticles were prepared by eco-friendly green combustion route using *Nigella sativa* (Kalonji) *seed* extract as a fuel. The copper nitrate trihydrate ($Cu(NO_3)_2.3H_2O$) was procured from Sigma Aldrich (AR) and used without further purification. Stoichiometric amount of $Cu(NO_3)2.3H_2O$ was dissolved with 0.2 g of *Nigella sativa* (Kalonji) *seed* extract in 10 ml of distilled water. The mixture was kept in a pre-heated muffle furnace at 400 ± 10^0 C and subjected for combustion. The reaction was completed within 5 min. A fine black coloured material was obtained. The synthesis of nanoparticles was repeated with different concentrations of the plant extract such as 0.3, 0.4, 0.5 and 0.6g. The obtained product was stored in airtight container until further use.

3 Results and discussion

3.1. PXRD , SEM and UV-Visible absorbtion spectrum.

Fig.1. shows typical XRD patterns of the formed CuO Nps which was identical to the single phase monoclinic (JCPDS: 80-1916) structure with a lattice constant *a* = 4.6965°A, *b* = 3.4324°A and *c* = 5.1329°A,β = 99.5287◦A. No impurity peaks other than CuO were observed in the XRD pattern indicating the high phase purity. The broadening of the diffraction peaks indicates that the crystal size was small. The average crystallite size of the CuO Nps calculated by Debye–Scherrer's formula as

$$\mathbf{D = k\lambda / \beta \cos \theta} \qquad \textbf{[1]}$$

where *D* - the particle size (nm), *k* - a constant equal to 0.94, λ - the wave length of X-ray radiation (1.5406°A),β - the full-width at half maximum (FWHM) of the peak(in radians) and 2θ - the Bragg angle (degree). The average crystallite size was found to be in the range 20–47 nm.

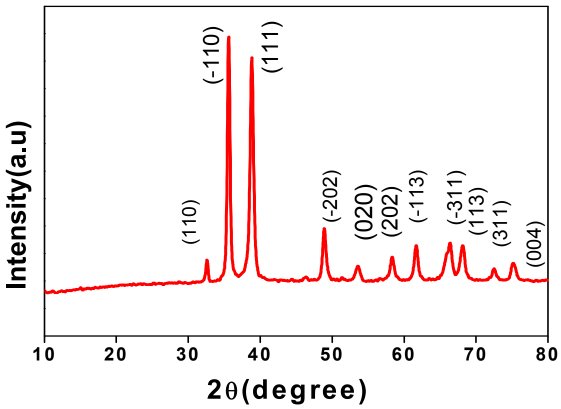

Fig. 1. PXRD patterns of CuO nanoparticles prepared with plant extract 10 mL

Fig.2.shows the SEM image of CuO Nps. It clearly shows that the particles were almost porous in nature with agglomeration. Further, it was observed that micro structure was independent of the concentration of plant extract.

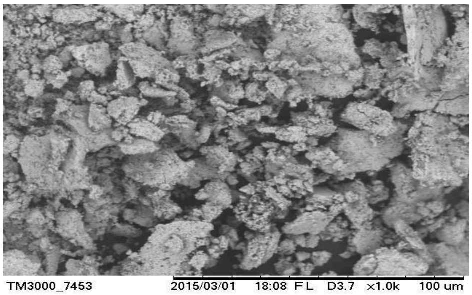

Fig.2.SEM image of CuO nanoparticles prepared in 10 mL of plant extract.

Fig.3. shows the UV-Visible absorbtion spectrum of CuO Nps exhibiting the maximum absorbance peak at 388 nm indicates blue shift with increasing concentration of the plant extract in the reaction mixture during the synthesis by combustion process.

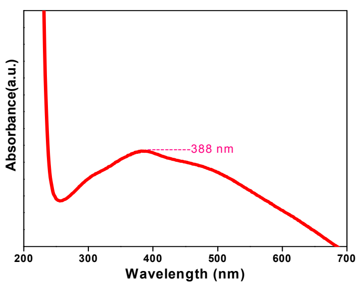

Fig.3. UV-Visible absorbtion spectrum of of CuO nanoparticles prepared in 10 mL of plant extract.

3.2. Antibacterial activity

The antibacterial properties of the CuO Nps were evaluated against Gram –ve bacteria *E. coli*, and Gram +ve bacteria *S. aureus* using agar well diffusion method [12]. In the present case, *E. coli* and *S. aureus* show significant zone of inhibition by CuO Nps. Fig. 4 shows the zone of inhibition of CuO Nps against the Bacterial strains namely Gram −ve, *E.coli* and Gram +ve bacteria *S. aureus* with 400 and 8000 µg concentration of CuO Nps. The details of zone of inhibition (mm) for the above bacterial strains are given in **Fig.4.** It was evident data was shown in the Table 1.

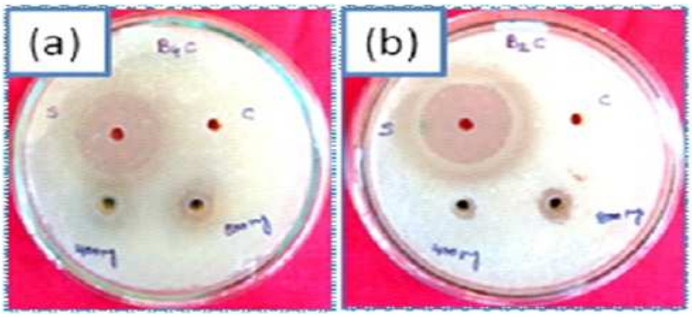

Fig.4 Antibacterial activity of Cuo Nps against bacterial stains (a)*s.aureus* (b) *E.coli*

Table-1: Antibacterial activity of CuO nanoparticles against pathogenic bacterial strains

Treatment	***E.coli*** **(B2) (Mean±SE)**	***S.aureus(B4)*** **(Mean±SE)**
Standard (5µg/50µL)	10.67±0.33**	11.67±0.33**
CuO (400µg/40µL)	1.33±0.33**	1.00±0.00
CuO 800µg/80µL)	2.67±0.33**	2.33±0.33**

values are the mean ± SE of inhibition zone in mm. *Symbols represent statistical significance, *$P < 0.05$, **$P < 0.01$ as compared with the control group.

4. Conclusions

This study reports that green synthesis of CuO Nps prepared by solution combustion method using *Nigella sativa* seed extract as a fuel. The PXRD patterns showed monoclinic phase and the UV–visible absorption spectrum indicates blue shift with increasing concentration of the plant extract in the reaction mixture during the synthesis. SEM images reveal that the particles appear to be irregular in shape. CuO Nps exhibited significant antibacterial activity against both Gram –ve and Gram +ve bacterial strains such as *E. coli*, and *S. aureus*. Among them, *E. coli* and *S. aureus* show significant zone of inhibition to CuO Nps compared to the positive control (Ciprofloxacin). The study successfully demonstrates the convenient utilization of *Nigella sativa* seed extract as a fuel to get structurally and morphologically interesting and potentially antibacterial properties.

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