Octa Journal of Biosciences
Octa J. Biosci. Vol. 8(1): 38-41

International peer-reviewed journal
Jan-June 2020

Octa Journal of Biosciences
ISSN 2321 – 3663
journal homepage: www.sciencebeingjournal.com

Original Research Article

Received:11/2/2020 / Revised:7/5/2020 / Accepted:3/5/2020 / Published on-line:6/6/2020

An eco-friendly synthesis of cupric oxide nanoparticles by using leaves extract of *Psidium guajava*, characterisations and antibacterial activities

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ABSTRACT

The synthesis of nanoparticles by using any plant materials such as leaves, stem, root or bark is highly efficient, eco-friendly and cost effective. The metal and metal oxide nanoparticles are used in different fields of science and technology due to their specific properties. The green or biological methods have been recognised as good alternatives over physical and chemical methods. In this work, we have synthesised CuO nanoparticles (CuO NPs) by using leaves extract of *Psidium guajava*. The green synthesised CuO NPs were characterised by using FTIR, FESEM and powder XRD methods. The biogenic CuO NPs were tested for their antibacterial effects against different bacterial species such as *E. coli, S. aureus* and *P. vulgaris*. The experimental data have been indicated that the more effectiveness of CuONPse for *E. coli* as compared to *S. aureus* and *P. vulgaris*.

Keywords: *Green synthesis; Nanoparticles; CuO NPs; Characterisations; Antibacterial activity*

1. INTRODUCTION

The main applications of nanotechnology in the synthesis of nanowires, nanoparticles and nanotubes have attracted great attentions. The nanoparticles are found in the particle sizes between 10 to 100 nm and have large surface area to volume ratio. The metal and metal oxide nanoparticles are used in electronics, sensors, and pharmaceuticals, biological, environmental and medical fields (Hemalatha and Makeswari, 2017; Joshi et al., 2019; Naika et al., 2015; Padil and Cernik, 2013). The green or biological methods utilising any plant derived materials such as leaves, bark, roots, stem and floral parts are better alternatives over physical and chemical methods due to high efficiency, low-cost, environmental safety and reliability. The commonly green synthesised metal oxide nanoparticles are cupric oxide (CuO), manganese oxide (MnO_2), calcium oxide (CaO), magnesium oxide (MgO), zinc oxide (ZnO), iron oxides and titanium oxide (TiO_2) (Joshi et al., 2019; Joshi et al., 2020). Cupric oxide nanoparticles (CuO NPs) have many applications such as sensors, catalytic, electrical, solar energy transformation, and superconductors and in the preparation of inorganic-organic composites (Naika et al., 2015).CuO NPs are also used as good antimicrobial agents and water purifiers4. In this study, we have synthesised CuO NPs by using leaves extract of *Psidium guajava*. The biologically synthesised CuO NPs have characterised and utilised as antibacterial agents. The plant *Psidium guajava* is also known as guava and usually found in tropical countries and evergreen tree. It belongs to an Angiospermic family i.e. Myrtaceae (Dakappa et al., 2013). This is a shrub and can attend a height upto 5 to 24 meters. The leaves are very wide, green and with a clear prominent veins (Arima and Danno, 2002; Rouseff et al., 2008; Salas-Orozco et al., 2019). In this study, we have synthesised CuO NPs by using the leaves extract of *Psidium guajava* and the green synthesised CuO NPs characterised by using FTIR, powder XRD and FESEM methods. The CuO NPs were utilised as antibacterial agents for the bacterial species *E. coli,S. aureus* and *P. vulgaris*.

2. MATERIALS AND METHODS

Preparation of leaves extract:

The fresh leaves of *Psidium guajava* were washed with distilled water and then cut into small pieces. Added 5 g of cut leaves into 100 ml double distilled water and boiled for 45 minutes. The content was filtered and filtrate (leaves extract) was preserved for making CuO NPs.

Synthesis and characterisation of CuO NPs:

Added 10 ml of extract into 100 ml of 0.1M copper acetate solution and stirred for 30 minutes over magnetic stirrer at room temperature. After that, added several drops of 0.1M NaOH solution till the precipitate come out. The CuO NPs have been collected by using centrifugation machine at rpm 10,000 for 20 minutes. After several washing with double distilled water and centrifugations, CuO NPs have been calcined at 300^0C for 1 hour. Finally, CuO NPs were preserved for characterisations and antibacterial activities. The characterisation of CuO NPs was done by means of FTIR, powder XRD and FESEM methods.

Antibacterial activity:

The antibacterial activity of CuO NPs was done by using well diffusion method against *Escherichia coli*, *Staphylococcus aureus*, and *Proteus vulgaris* (Lorian, 1996). The liquid media was poured over petri plates and then solidified. The CuO NPs have been loaded in the wells onto plates and the remarkable zones of inhibition obtained after incubation period.

3. RESULTS AND DISCUSSION

Characterisations of CuO NPs:

The green synthesised CuO NPs have been characterised by using FTIR, FESEM and powder XRD methods. Fourier-transform infrared spectroscopy (FTIR) is a basic analytical technique which used in the determination of type of bonds found in inorganic, organic as well as polymeric species (Joshi et al., 2019; Hemalatha and Makeswari, 2017). The characteristic peaks are obtained at 3409 cm^{-1}, 1624 cm^{-1}, 1144 cm^{-1}, 1094 cm^{-1}, 776 cm^{-1} and 619 cm^{-1}. These peaks are indicating the presence of O-H, C=O, C-C, C-Cu and Cu-O bonds on the surface of CuO NPs (Fig. 1A) (Hemalatha and Makeswari, 2017). Field-emission Scanning Electron Microscope (FESEM) is based on the scanning of objects by electrons and used in the observation of morphology of nanoparticles (Joshi et al., 2020). Figure 1B represents the FESEM image of CuO NPs and indicates sphere shaped morphology of nanoparticles. Powder X-ray diffraction technique is an analytical technique used in the identification of phase and unit cell dimensions (Joshi et al., 2020). The XRD pattern of green or biologically synthesised CuO NPs is represented in figure 1C. The specific peaks are obtained at 38θ, 44θ, 62θ and 78θ and representing the 111, 201, 113 and 222 planes. The CuO NPs are also known for their good antibacterial activities (Joshi et al., 2019; Hemalatha and Makeswari, 2017).

Antibacterial activity of CuO NPs:

The green synthesised metal oxide nanoparticles are well known for their antibacterial activities. They can easily enter into the bacterial cell and causes distortions and destroy the cell membrane. Finally, this mechanism causes death of bacterial cells (Salas-Orozco et al., 2019; Golinska et al., 2018). After incubation periods, the zones of inhibition have been found to be 22 mm, 18 mm and 16 mm for *E. coli*, *S. aureus* and *P. vulgaris* at dosage 6 mg/ml.

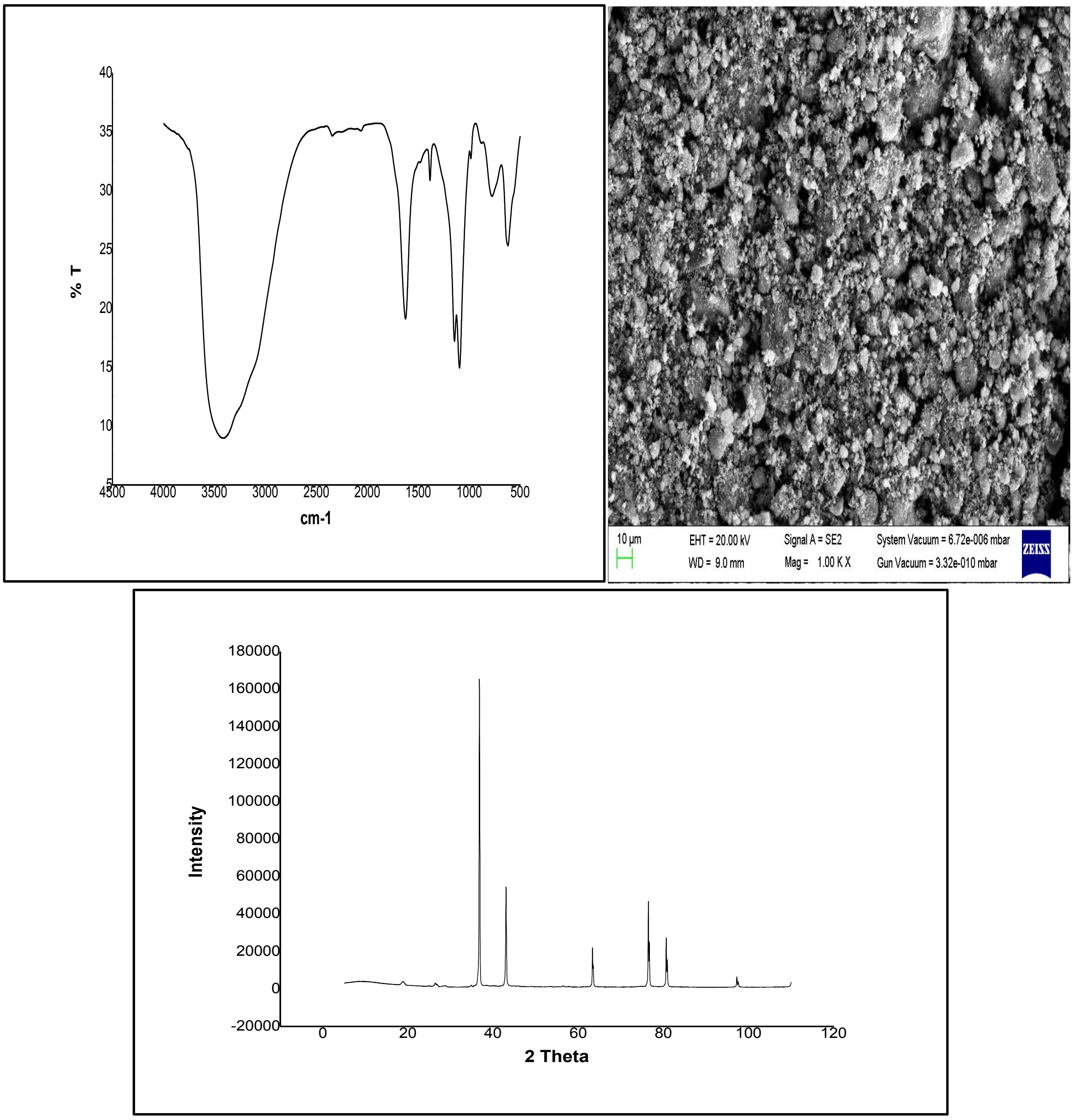

Fig. 1: (A) FTIR spectrum (B) FESEM image and (C) XRD pattern of CuO NPs

Table: 1 Antibacterial activity of CuONPS against different bacterial strain.

Bacterial strain	Zone of inhibition
Streptococcus aureus	18 mm
Proteus vulgaris	16 mm
Escherichia coli	22 mm

4. CONCLUSIONS

The synthetic method used for CuO NPs by using leaves extract of *Psidiumguajava* is found very safe, efficient and low cost. The synthesised CuO NPs were characterised by using FTIR, FESEM and XRD methods. Remarkable zones of inhibition have been found for *E.* coli, *S. aureus* and *P. vulgaris* after incubation period.

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6. ACKNOWLEDGEMENTS

We are very thankful to the Department of Chemistry, Uttaranchal University Dehradun (India) for providing the necessary facilities during the experimental works.