

Original Research Article

SYNTHESIS OF COPPER OXIDE NANOPARTICLES USING *OCIMUM GRATISSIMUM* (SCENT LEAF)

ABSTRACT

Environmentally friendly synthesis of copper oxide nanoparticles (NPs) has been achieved using aqueous extracts of *Ocimum gratissimum* (scent leaf). The reduction of Cu^{2+} was followed by the change of color from green to dark brown color and formation of precipitate. The reaction was monitored by visual observation and characterization of copper nanoparticles using UV-Visible spectrophotometer and Fourier Transform Infrared spectrophotometry. UV-Visible spectra of the aqueous solution containing copper nanoparticles showed a peak at 240 nm corresponding to the surface plasmon resonance of copper oxide nanoparticles. FTIR spectra also confirmed the formation of the copper oxide NPs by the appearance of bands corresponding to Cu-O stretching frequency and the presence of phytochemicals present in *Ocimum gratissimum* on the surface of the copper oxide nanoparticles which presents these nanoparticles as promising biological agents. This green synthesis method replaces the use of toxic chemicals with *Ocimum gratissimum* extract which play the roles of reducing, stabilizing and capping agents during the synthesis.

Keywords: green synthesis, nanoparticles, copper oxide, UV-Vis, FTIR spectroscopy

INTRODUCTION

Particles with size less than 100 nm are referred to as nanoparticles. Unlike bulk components, they have special optical, thermal and electrochemical properties. That is why they have found a number of applications in the areas of environment, medicine, energy, agriculture, chemistry, information, communication, heavy industry, and consumer goods.

Nanoparticles exhibit completely new or improved properties based on specific characteristics (size, distribution, morphology, etc), when compared with larger particles of the bulk material they are made of. Nanoparticles of metals like silver, copper, zinc and platinum are well recognized to have significant applications in electronics, magnetic, optoelectronics, information storage, biotechnology as well as water decontaminant [1,2]. They are also broadly applied in shampoos, soaps, detergents, cosmetics, toothpastes, medical and pharmaceutical products, and are hence directly encountered by human systems [3].

Nanoparticles are usually prepared by different methods such as chemical and physical methods which are often considerably costly and capable of causing harm to the environment. Often these methods of preparation involve the use of toxic and unsafe chemicals that are responsible for various biological risks. Due to this, the development of biologically-inspired experimental processes for the syntheses of nanoparticles is developing into an important branch of nanotechnology [4].

Nanoparticles (NPs) are at the forefront of rapid development in nanotechnology. The design of NPs has gained a lot of attention, leading to the development of particles with various shapes such as spheres, rods, tubes, fibers, and disks, and variety of geometries ranging from worms, squares, urchins and

ellipsoids. The optical properties of NPs also depend on its size and shape. Their unique geometries and size-dependent characteristics make NPs indispensable and outstanding in varieties of applications. Physical properties of nanoparticles (NPs) include shape, size, specific surface area, and agglomeration/aggregation, state of size distribution, surface morphology/topography, and structure including crystallinity, defect structure, and solubility [5].

In recent years, plant-mediated synthesis of nanoparticles is gaining importance due to its simplicity and eco-friendliness [6-8]. Although synthesis of metals and metal oxides has been reported, the potential of the plants as materials for the synthesis of nanoparticles is yet to be fully explored.

Many plant parts or whole plants have been used for benign synthesis of copper and copper oxide NPs due to the presence of a large number of bioactive compounds in plants. The extracts of plants have been efficiently applied for this purpose. Synthesis of copper NPs has been successful with extracts of various parts of plant species that include *Punica granatum* peel [9], *Zingiber officinale* stem [10], *Citrus medica* Linn. (Idilimbu) juice [11], *Ziziphus spina-christi* (L.) Willd fruit [12], *Asparagus adscendens* Roxb., root and leaf [13], *Eclipta prostrata* leaf [14], *Ginkgo biloba* Linn leaf [15], *Plantago asiatica* leaf [16], *Terminalia catappa* leaf [17], and *Azadirachta indica* leaf [18].

Ocimum gratissimum, locally called Efirin (Yoruba), Nchanwu (Igbo), Daidoya (Hausa) is a herbaceous perennial shrubs (or subshrubs), usually 1-3 m tall; green branched stem, round-quadrangular leaves with woody base. Commonly known as 'scent leaf', *Ocimum gratissimum* is widely consumed as spice and grown for medicinal purposes and for the essential oil in its leaves and stems. The essential oil possesses antibacterial properties and is also an established insect repellent when the leaves are dried or burnt. Due to the aromatic nature of *Ocimum gratissimum*, it is primarily consumed as vegetable and as spice to spice various kinds of soup and other delicious meals. The whole plant has many applications in traditional medicine globally including Africa and Asia. *Ocimum gratissimum* is widely applied either alone or in combination with other plants for the treatment of ringworms, gout and fungal infections, malaria, diarrhea, catarrh, vomiting, inflammation, convulsion, colon pain and skin diseases.

Though some studies and researches have been carried out on the synthesis of CuO NPs using different plant extracts and broth [19-20], nevertheless, no detailed studies have been carried out on the synthesis and characterization of CuO NPs using *Ocimum gratissimum* (scent leaf). Thus, it is vitally important to explore a more reliable and sustainable process for the synthesis of copper nanoparticles. Therefore, the present research work was proposed to explore the synthesis of green CuO NPs (CuO NPs) using extracts of medicinal plant of *Ocimum gratissimum* (scent leaf).

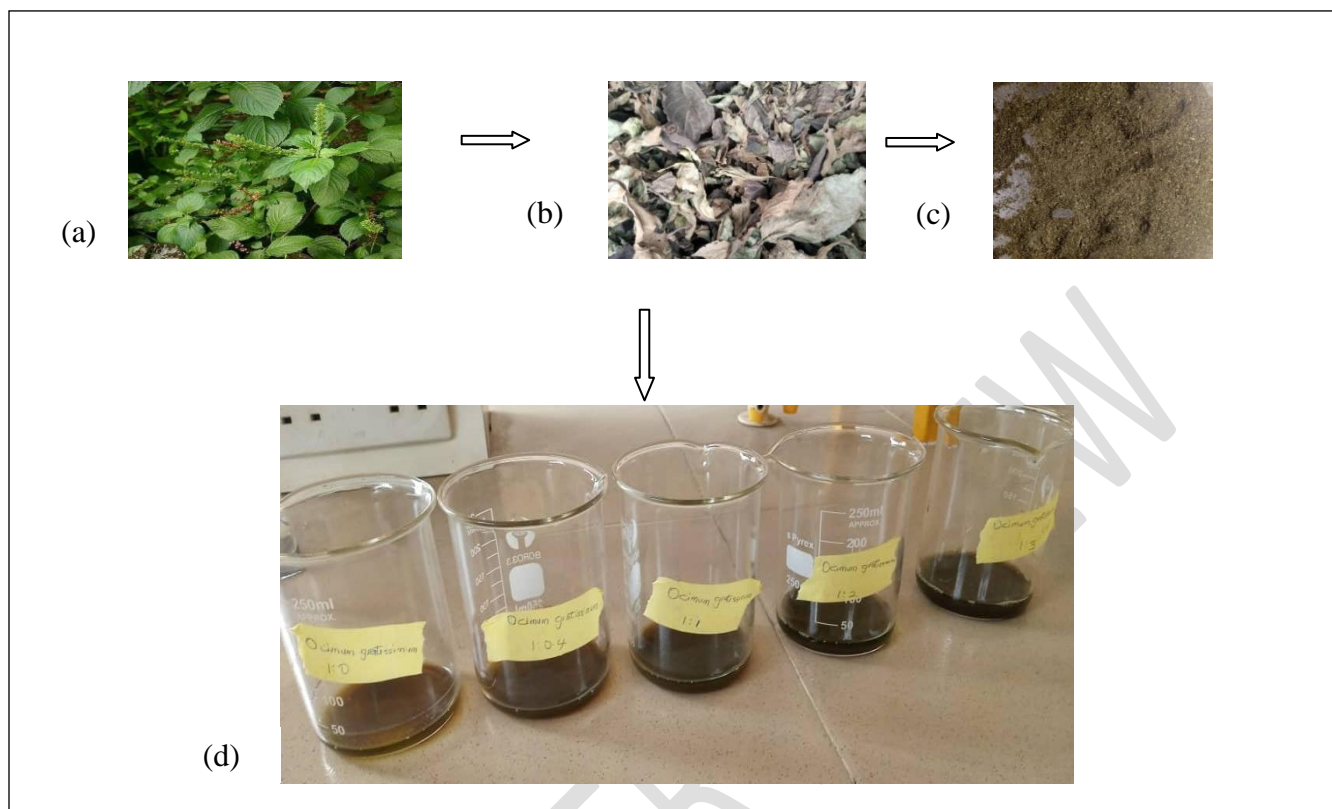


Figure 1: (a) Fresh *Ocimum gratissimum* (b) dried *Ocimum gratissimum* (c) grounded *Ocimum gratissimum* (d) Copper oxide nanoparticles synthesized at different ratios of CuSO_4 - 1:0; 1:0.5; 1:1; 1:2 and 1:3

MATERIALS AND METHODS

Copper sulphate pentahydrate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, 99.5%) was obtained from commercial source and used as received; *Ocimum gratissimum* (well known as scent leaf) leaves were bought from Otuoke community market, Bayelsa State, Nigeria. Distilled water was used to prepare all extracts and solutions. UV-Visible spectra was taken between wavelength of 200 and 600 nm on a JASCO V-730 Spectrophotometer at a bandwidth of 1 nm and scan speed of 1000 nm/min. Distilled water was used as the blank. Infrared spectra were collected on Shimadzu 8400S FT-IR spectrophotometer in the region $4000 - 350 \text{ cm}^{-1}$.

Preparation of *Ocimum gratissimum* extract

Extracts from the ambient-dried leaves of *Ocimum gratissimum* was prepared by weighing 15 g of the grounded dried leaves into 500 mL beaker with the addition of 150 mL of distilled water and then stirred for about 10 minutes. The mixture was kept at ambient conditions, away from light for 48 hours at 25°C . The extract was collected by filtration using Whatmann filter paper.

Green synthesis of copper oxide nanoparticles

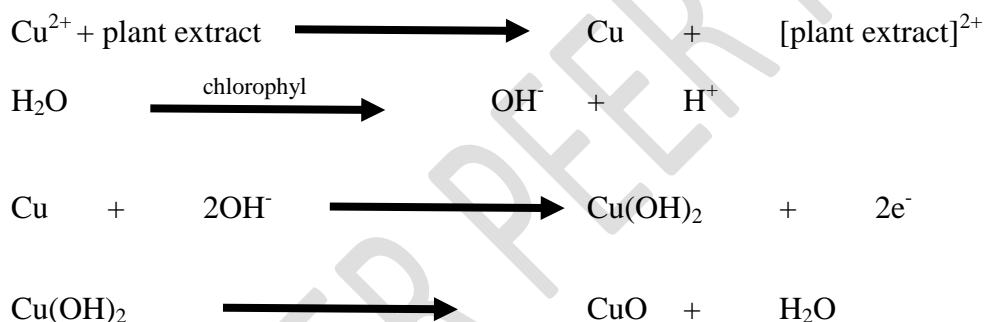
Copper sulphate was used to prepare a concentration of 0.1 M. For reduction of CuO ions, 5 mL of scent leaf extract was added into a clean beaker and then 10 mL of 0.1 M of aqueous $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ solution was added into the extract. On addition of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ to the extract, precipitate was noticed after about 40

minutes. The copper oxide nanoparticle synthesis was carried out at different mixing ratios of the extracts to 0.1 M $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ (1:0, 1:0.5, 1:1, 1:2, 1:3) at 10% extract concentration. 1 mL of the extracts were collected periodically to monitor the complete ion bio-reduction of Cu(II) ion in aqueous solution, and subsequent UV-Vis spectra scan.

RESULTS AND DISCUSSION

Formation of CuO NPs

The formation of CuO-NPs was studied by the visual observation of reacting solutions at different intervals of time. Initially, the color of the extract of *Ocimum gratissimum* (scent leaf) was green which later changed to dark brown after the complete formation of copper nanoparticle. Finally, the deposition of brown precipitate was observed on the inner wall of the vessel after 40 minutes stirring indicating the formation of copper nanoparticles. The change in coloration is attributed to the bio reduction of Cu^{2+} ions to nanoparticles and the subsequent oxidation of the reduced copper nanoparticles to copper oxide nanoparticles [21]. Scheme 1 represents the probable pathway for the formation of the CuO NPS. First, Cu^{2+} was reduced to metallic copper nanoparticles by the phytochemicals present in the *Ocimum gratissimum* leaf extract, then the hydroxyl ion formed by the photocatalytic reduction of water by chlorophyll present in *Ocimum gratissimum* leaf react with the metallic copper to form copper hydroxide. The aqueous basic *Ocimum gratissimum* leaf extract then provided a suitable condition for the decomposition of the metastable copper hydroxide into copper oxide and water. The insoluble CuO NPs were then collected using membrane filter.



Scheme 1: The proposed scheme for the synthesis of CuO NPs

UV-Visible Absorption Spectroscopic Studies

The complete ion bio-reduction of Cu(II) ion by *Ocimum gratissimum* leaf extract was monitored by UV-Vis spectrophotometry in the range of 200-600 nm. Figure 3 illustrates UV-visible absorption spectrum of the formed CuO NPs showing absorption peak at 240 nm due to interband transition of the core electrons of CuO NPs. (The instrument lamp exchange is between 340 and 370 nm). Other researchers observed similar strong absorption peaks in the UV spectrum of CuO NPs between 250 and 300 nm in mint leaves, orange peel and tangerine peel and alluded this to CuO NPs surface plasmon resonance confirming the formation of CuO NPs [19-20].

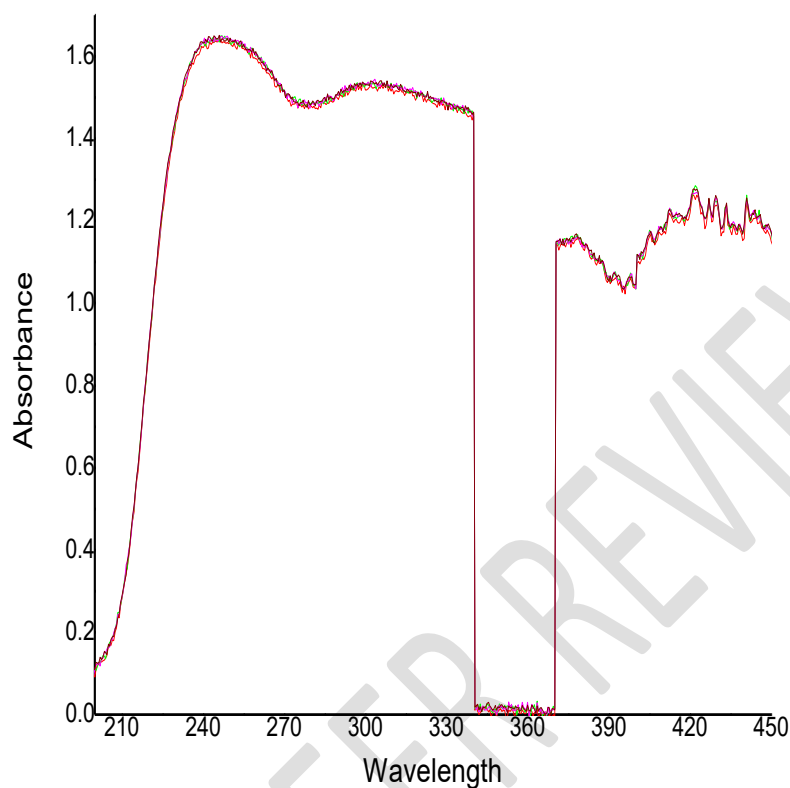


Figure 2: UV-visible absorbance spectrum of CuO NPs.

Fourier Transform Infrared Spectroscopic Studies

The FTIR spectra of the synthesized CuO NPs at different ratios shows absorption peaks of the functional groups adsorbed on the synthesized CuO NPs at 3441 cm^{-1} (1:1), 3437 cm^{-1} (1:2), 3425 cm^{-1} (1:3) which represents O-H stretching vibration of phenolic compounds present in *Ocimum gratissimum* leaves extract. Absorption at 2937 cm^{-1} is due to the presence of C-H asymmetric stretching. Absorption at 1635 cm^{-1} is due to C=C stretching of aromatic ring.

Absorption band at 1402 cm^{-1} is due to C—C vibrations of benzene ring. Absorption at 1107 cm^{-1} is due to C-O of eugenol in *Ocimum gratissimum*. 451 cm^{-1} (1:1), 509 cm^{-1} (1:2), 441 cm^{-1} (1:3) indicates the Cu-O stretching in the NPs. 617 cm^{-1} (1:1), 599 cm^{-1} (1:2), 619 cm^{-1} (1:3) also indicates that the nanoparticles are in the form CuO as they represent Cu-O stretching. FTIR revealed the presence of phenolic compounds which were responsible for reducing copper ions into copper nanoparticles. It is believed that these phytochemicals present in the leaf extract of *Ocimum gratissimum* (scent leaf) are responsible for binding to the surface of the formed CuO NPs and thereby leading to the stabilization of the biosynthesized nanoparticles.

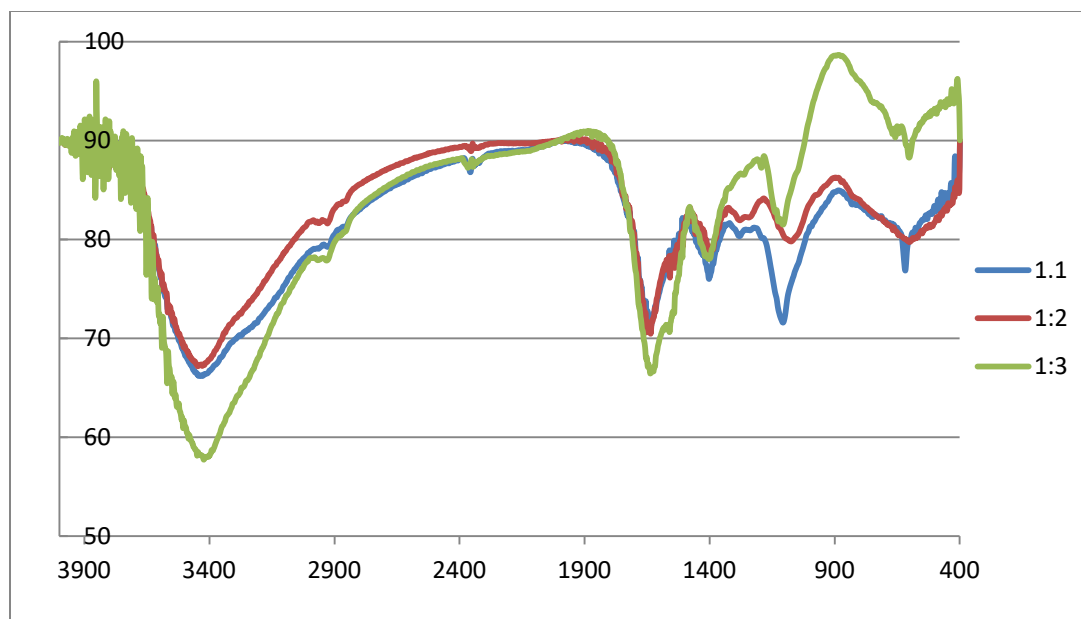


Figure 3: FTIR spectra of Copper Oxide nanoparticles **formed from scent leaf extract.**

CONCLUSION

The preparation of CuO NPs was successful with aqueous extract of *Ocimum gratissimum* (scent leaf). This method holds several merits because of its easy preparation, cost-effectiveness and environmentally friendliness. The absorption spectra confirm the formation of copper oxide nanoparticle with the absorption peak at 240 nm. FTIR analysis results also confirmed the formation of copper oxide nanoparticles with the presence of bands typifying Cu-O bond stretching as well as the presence of various phytochemicals of *Ocimum gratissimum* adsorbing to the surface of the formed copper oxide nanoparticles. The *Ocimum gratissimum* phytochemicals serve as reducing, stabilizing and capping agent for the formed nanoparticles showing that these nanoparticles holds promise as antimicrobials with potent biological activity.

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UNDER PEER REVIEW