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GREEN SYNTHESIS AND CHARACTERIZATION OF SECURIDACA LONGIPEDUNCULATA COPPER OXIDE-BASED NANOPARTICLES

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ABSTRACT

Copper oxide nanoparticles (CuONPs) have drawn significant attention because of its diverse applications in medicine, environmental remediation, catalysis, and nanotechnology. Green synthesis provides an environmentally friendly, cost-effective, and sustainable alternative to conventional chemical methods. This study aimed to synthesize and characterize CuONPs using the leaf extract of **Securidaca longipedunculata** as a natural reducing and stabilizing agent. Copper oxide nanoparticles were synthesized by reacting aqueous leaf extract with copper (II) sulphate pentahydrate ($CuSO_4 \cdot 5H_2O$) under controlled laboratory conditions without the use of hazardous chemical reducing agents. The synthesized nanoparticles and the crude leaf extract were characterized using Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM) to evaluate their morphology, surface characteristics, and particle size. Microscopic analyses confirmed the successful formation of CuONPs with predominantly nanoscale dimensions and characteristic morphological features, indicating effective reduction and stabilization by the phytochemicals present in the plant extract. The findings demonstrates that **Securidaca longipedunculata** leaf extract was an efficient, eco-friendly bioreducing agent for the green synthesis of CuONPs. This environmentally sustainable approach offers a promising route for producing copper oxide

nanoparticles with potential applications in biomedical, pharmaceutical, and environmental technologies.

KEYWORDS: Securidaca longipedunculata, Copper oxide nanoparticles (CuONPs), Green synthesis, Nanoparticle characterization, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy. (TEM)

INTRODUCTION

The particles which are from 1 to 100 nm in size, are termed as nanoparticles. The particle is an object which acts as a complete unit with regard to its properties Nanoparticles are essentially a bridge between atoms/molecules and bulk form of the material (Paramasivam et al., 2021). They have unique properties such as mechanical, electrical, optical, and magnetic properties due to their small size and higher specific surface area, nanomaterials (Dargo et al., 2017).

In recent years, nanomaterials have been effectively applied to numerous perspectives as catalysis, medicine and sensor (Liang et al., 2012). They are applied in textile, biotechnology, health care, food, electronics, environment and renewable energy (Ankush et al., 2020). They have extensive applications to prevent several environmental problems like wastewater treatment. Because, nanomaterials have the potential to eliminate different toxins, for instance, heavy metals, organic pollutants, inorganic anions, and pathogens (Diana et al., 2017).

Copper oxide nanoparticles have attracted considerable attention because copper is one of the most important in modern technologies and is readily available (He et al. 2010). In recent years, nanostructures of transition metal oxides have gained a great attention from material scientists and engineers due to their different properties compared with the corresponding bulk counterparts which provides promising applications in various fields of technology and preparation of high quality nanostructures with defined, controllable size, and morphology (Yecheskel, 2013).

Copper oxide is one of the important metal oxides which has attracted recent research because of its low cost and it is used in various fields such as catalyst, superconductors, ceramics and other inorganic materials (Mallick and Sahu 2012). Among all metal oxide nanoparticles, copper oxide has gained interest because of its applications, such as in solar cell technology, field emission, lithium ion batteries, gas sensing, drug delivery (Mahdi et al, 2013).

Securidaca longipedunculata fresen belongs to the family polygalaceae, it is a small tree with alternate leaves which are variable in size, shape and crowded towards the stem tips (Van et al., 2009). Its flowers are small, pink or purple in colour, sweet scented and are usually produced in early summer (Van et al., 2005). The fruits of this plant are heavily veined, smooth, oblong, purplish green when young and also possess a membranous wing (Palgrave, 2005). Securidaca (family polygalaceae) is a widespread genus comprising of about 80 species widely distributed in woodlands and arid of tropical and subtropical Africa (Yang et al., 2001). The genus Securidaca comprises about 80 species, characterised by papillionaceous purplish flowers and mostly scandent shrubs and lianas, which produce compounds known as securixanthones with antimicrobial and antioxidant properties; (Yang et al., 2013).

The plant genus is known to contain a large number of chemically complex bioactive compounds. Traditional medicine refers to health practices, approaches, knowledge and beliefs incorporating plant, animal and mineral based medicines, spiritual therapies, manual techniques and exercises, applied singularly or in combination to treat, diagnose and prevent illnesses or maintain well- being (WHO., 2003). In Africa, up to 80% of the population uses traditional medicine for primary health care, making it an important global market for herbal medicines (WHO, 2003). The most effective method of identifying medicinal plants today is ethnopharmacological studies. Medicinal plants serve as a source of medicines in a variety of communities for the treatment of numerous pathogenic infections, tonics for general wellbeing, as spices and condiments and for magical purposes.

The synthesis of the nanoparticles using different plant extracts holds great potentials since the phytochemicals in plant extract play a significant role in the reduction of metals ions and capping the bio mediated copper oxide nanoparticles which serve as the stabilizing agent (Pirtarighat et al., 2019). In addition, in the majority of cases, a reducing agent from the plant extract plays a role as both the capping and stabilizing agents (Salayová et al., 2021). The plant is commonly known as violet tree in English. The plant is called Uwar magunguna, Ezeogwu, Aaalali, Ipeta by the Hausa, Igbo, Fulani, and Yoruba people respectively. Traditional medicine refers to health practices, approaches, knowledge and beliefs incorporating plant, animal and mineral based medicines, spiritual therapies, manual techniques and exercises, applied singularly or in combination to treat, diagnose and prevent illnesses or maintain well-being (WHO, 2003).

The plant is traditionally used to treat fungal infections, Fever, Malaria, Gonorrhoea, Headaches, Cancer, Rheumatism, Tuberculosis, Diabetes, Venereal Diseases, Syphilis, Sexual impotence, Toothache, Pains, Epilepsy, (Moshi et al., 2007, Viol, 2009, and Maroyi, 2013). Also, the leaf of S. longipedunculata is locally used to treat, snakebite, skin infections (Mustapha, 2013). Its stem bark is traditionally used to Treat Epilepsy, Stomach Ache, Malaria, Typhoid, Inflammation, Chest complaints, Abortion, Viral infections, Snake bites and Infertility problems (Das, 2009, Bruschi et al., 2011, Oladunmoye and Kehinde., 2011., Borokini et al., 2013 and Kadiri et al., 2013). The current paper therefore aims at synthesizing plant-based CuO nanoparticles using Securidaca longipedunculata an important natural reducing and stabilizing agent.

MATERIAL AND METHODS

Plant Material

The leaves of S. longipedunculata plant sample were collected from Gashaka Gumti National Park in Serti Taraba State, Nigeria. The leaf samples were dried at room temperature then grounded into powder form using iron mortar and pestle. The powdered plant sample was labelled and stored and it's used for the extraction.

Material and Reagents

Sulfuric acid (H_2SO_4), Sodium Hydroxide (NaOH), Chlorofom, Hydrochloric acid (HCl) copper sulphate dehydrates ($CuSO_4.5H_2O$), methanol and the leave extract. All the chemical reagents used in this experiment are analytical grade.

Extraction of Plant Material

Soxhlet extraction method with slight modification according Kumar et al. (2020), was used for extracting the bioactive components of the plant materials.

Preparation of Copper Oxide Nanoparticles (CuONPs)

The synthesis of the S. longipedunculata- based copper oxide nanoparticles was carried according to method described by Altikatoglu et al. (2017).

Characterization of the Copper Oxide Nanoparticles (CuONPs)

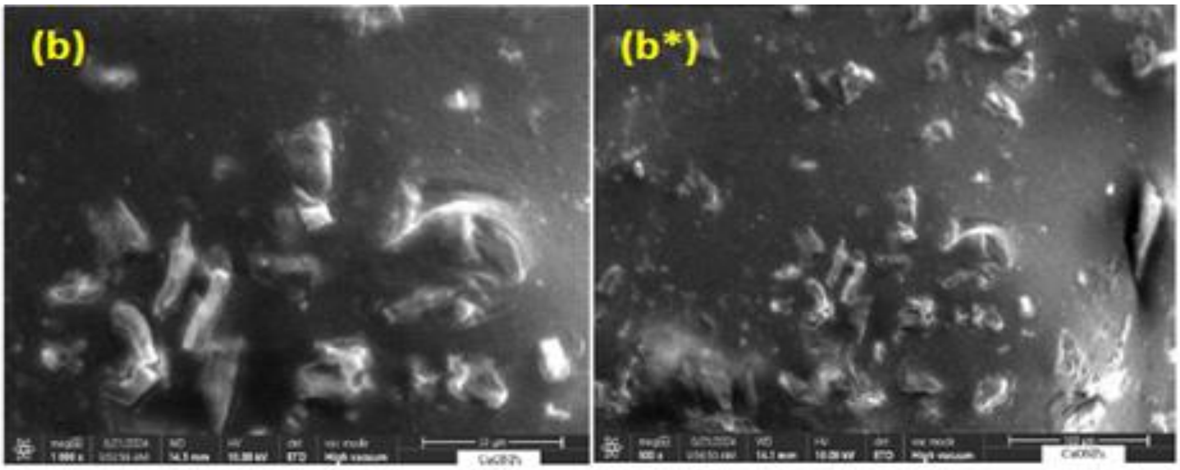
Characterization of nanomaterials involves determination of parameters such as chemical and physical characteristics, particularly size distribution, shape, surface area, surface chemistry, morphology, charge, crystallinity, porosity, agglomeration state, and surface charge analysis of the synthesized nanoparticles. These techniques were carried out using Transmission Electron Microscopy (TEM) as described by Wilson and Prud"homme (2021), and Scanning Electron Microscopy (SEM), was adopted according to Davari et al. (2021).

RESULT AND DISCUSSION

Characterization of extract and copper oxide nanoparticles (CuONPs)

Scanning Electron Microscopy (SEM) Analysis

The Scanning Electron Microscopy (SEM) images provided essential information on the surface morphology of the synthesized CuONPs. In figure 1 below, SEM images of the CuONPs at different magnifications (b) 1000x and (b*) 500x, a relatively large surface area of the sample were observed. The SEM image showed an irregular spherical shaped features, scattered, uneven textured surface with a bright spot across the dark background which was due to the incorporation of extracts to form CuONPs. The white patches exhibited a variety of shapes, some were rough spherical, and others were more elongated or irregular which suggest potential agglomeration. Distribution of the particles were random in dark backgrounds on which the CuONPs were deposited and the smaller faint, white patches, smaller particles sizes which were likely an agglomeration of the CuONPs dispersed on the surface indicating newly incorporated phase. This finding agrees with a similar study conducted by Davari et al. (2021), in which the synthesized copper oxide nanoparticles showed agglomerated (cluster) particles, irregular, non-spherical shapes with less aggregation of particles and rough surface morphology.



Fiqure 1 SEM micrograph images of CuONPs (b) 1000x (b*) 500x.

Transmission Electron Microscopy (TEM) Analysis

The transmission electron microscopy (TEM) analysis provides valuable insights into the nanoscale structural changes in the CuONPs particles, which can be crucial for understanding their potential applications and behaviors in various environments. Figure 2 shows the TEM micrographs of CuONPs particles at 50 nm. Individual particles were visible, and their dimensions were noted all measured in nanometers (nm). These measurements showed a variety of particle sizes, suggesting a polydisperse distribution rather than a uniform. Additionally, there were fewer particles with circular to irregular shapes, which can be attributed to the formation of the nanoparticles. The histogram in Figure 2 (b) with a fitted curve represented the particle size distribution of the sample. The vertical axis represented particle dimension in nanometers, while the horizontal axis showed the counts. Distribution on the histogram suggests that most particles were around certain size, with the average size provided as 57.78+1.6 nm. The presence of a curve, likely a Gaussian or normal distribution fit, suggests that the particle size distribution was symmetrical around the mean as described by Akinterinwa et al. (2017), with a decrease in counts for particles much smaller or larger than the average.

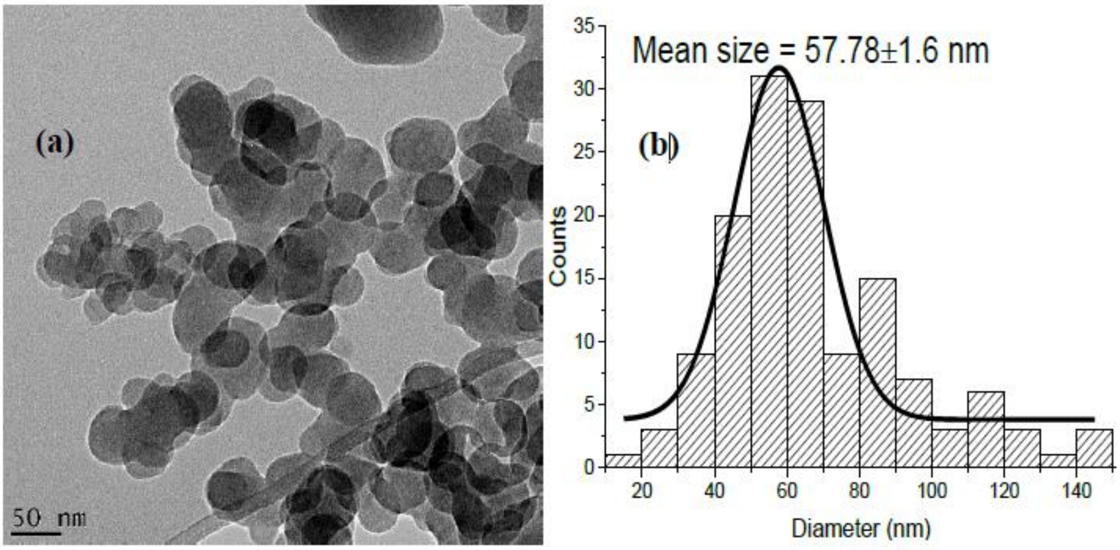


Figure 2: (a) TEM images of CuONPs and (b) the particle size distribution chart.

CONCLUSION

The present study demonstrated the successful green synthesis of copper oxide nanoparticles using Securidaca longipedunculata leaf extract as a natural reducing and stabilizing agent. Characterization by SEM and TEM confirmed the formation of nanoparticles with nanoscale dimensions and desirable morphological characteristics, validating the effectiveness of the green synthesis process. The use of plant-mediated synthesis eliminates the need for toxic chemical reagents, making the method simple, economical, and environmentally sustainable. These findings highlights the potential of S. longipedunculata as a valuable biological resource for the eco-friendly production of CuONPs and provide a foundation for future investigations into their antimicrobial, catalytic, and environmental applications.

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