Original Research Paper

Volume - 12 | Issue - 02 | February - 2022 | PRINT ISSN No. 2249 - 555X | DOI : 10.36106/ijar

Biotechnology

GREEN SYNTHESIZED COPPER NANOPARTICLES AND THEIR ANTIBACTERIAL ACTIVITY - A REVIEW

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ABSTRACT Biogenic synthesis of diverse nanoparticles via greener path has gained interest by researchers as they are eco-friendly, sustainable, and non-toxic. Present review article aims to update diversified copper nanoparticle (CuNPs) synthesis and their antibacterial activity thru greener method using different plant parts like leaves, fruits and roots. The phytoconstituents present in the plants acts as stabilizing and bioreducing agent for the synthesis of CuNPs. Various reports are available on the synthesis of CuNPs using precursors like copper sulphate, copper acetate and copper nitrate with different sizes of CuNPs ranging from 1-200 nm with spherical, rod and hexagonal shapes. CuNPs exhibited significant inhibition of gram positive and gram negative bacteria. This review highlights the synthesis of CuNPs using different parts of plants and their potential applications as antibacterial agents, which may act as a promising drug candidate through nano approach.

KEYWORDS : Copper nanoparticles, antibacterial, nanotechnology, medicinal plants, gram positive and gram negative

INTRODUCTION

Nanomaterials of size 1-100 nm are having wide range of applications in different fields[1]. Green synthesized nanoparticles are having many advantages over other methods. Biological method is simple, low cost, high yield and eco-friendly, when compared to other methods. Therefore, many researchers are interested working on biogenic synthesis of nanoparticles (NPs). The green synthesis of NPs can be done by using a different resources like plants and plant products, algae, fungi, yeast, bacteria, and viruses. Biogenic synthesis can be initiated by the adding metal salt with biological material. Various phytochemicals proteins, alkaloids, flavonoids, reducing sugars, polyphenols, etc., compounds, present in the biomaterials act as reducing and capping agents for the synthesis of NPs from its metal salt precursors.

Copper nanoparticles (CuNPs) are gaining interest due to their high electrical conductivity, chemical, thermal, biological properties and low cost[2]. The morphology, size, shape and yield of the nanoparticles depends on synthesis procedure and the process parameters. CuNPs are having extensive applications as anti-biotic, anti-microbial and anti-fungal agent when added to plastics, coatings and textiles. Green synthesized CuNPs exhibited catalytic[3], antibacterial[6,7,8], antimicrobial[4], anticancer[4], antioxidant[1,12,14,15] and antifungal activities[5].

Antibacterial Property Of Copper Nanoparticles

Copper nanoparticles (CuNPs) synthesized using aqueous extract of *Bambusa arundinacea* leaves solution, and their prospective biological activities are reported[6]. Indigenous medicinal plant *Hagenia abyssinica* (Brace) JF. Gmel of Ethiopia has been applied for the first time to investigate the synergistic influence of phytoconstituents in green CuNPs towards the enhancement of antimicrobial properties of NPs[7]. The synthesized CuNPs exhibited potential antibacterial activity against *Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus, Bacillus subtilis,* and *Proteus vulgaris*.

CuNPs were synthesized using leaf extract of *Ocimum sanctum*[8] and *Arevalanata*[9] as reducing and capping agent. These nanoparticles as novel antibiotic agents exhibited strong antibacterial activity against various bacterial species, including Gram positive (*Bacillus cereus, Staphylococcus aureus*) and Gram negative bacteria (*Escherichia coli, Pseudomonas aeruginosa*). The CuNPs were achieved by the reduction of copper sulphate with the aqueous leaf extract of *Nerium oleander*[10], *Heliconia psittacorum*[11]. The antibacterial activity of copper nanoparticles was studied against disease causing five bacterial pathogens like *Escherichia coli, Staphylococcus aureus, Klebsiella pneumoniae, Salmonella typhi* and *Bacillus subtilis.*

Wu et al.[12] synthesized copper nanoparticles successfully by *Cissus vitiginea*. The synthesized CuNPs were used to evaluate the antioxidant and antibacterial activity against urinary tract infection pathogens. Amaliyah et al.[22] used medicinal fruit extract of *Piper retrofractum Vahl* as bioreductor for the synthesis of copper nanoparticles using copper sulfate. The synthesized copper nanoparticles exhibited good stability and inhibited *Escherichia coli* and *Staphylococcus aureus*. Neem leaf extract was used to synthesize copper nanoparticles. The zone of inhibition of copper nanoparticles was 20 mm ± 1 with *Staphylococcus aureus* and 12.5 mm ± 1 with *Escherichia coli*[13].

Das et al.[14] reported the synthesis of copper nanoparticles from Hydroalcoholic extract of *Moringa oleifera* leaves and the anti-microbial activity of CuNPs. The synthesized copper nanoparticles were amorphous in nature with spherical shape. The synthesized copper nanoparticles exerted potential anti-bacterial activity against *Escherichia coli, Klebsiella pneumoniae, Staphylococcus aureus, and Enterococcus faecalis* (MIC values for the extract: 500, 250, 250, and 250 µg/mL; MIC values for the copper nanoparticles: 500, 500, 500, and 250 µg/mL). Rajeshkumar et al.[15] synthesized CuNPs using a rare medicinal plant *Cissus arnotiana* and evaluated their antibacterial activity. The zone of inhibition increased with the concentration of copper nanoparticles, and highest zone 22.20 ± 0.16 mm was obtained with 75 µg/ml CuNPs concentration.

Table 1. Antibacterial Activity Of Copper Nanoparticles Synthesized From Leaves Of Different Plants.

S.No	Plant source	Salt	Morphology	Size (nm)	Antibacterial activity against	Reference
1	*Bambusa_arundinacea*	Cupric acetate	spherical	23	*Escherichia coli, Streptococcus aureus, Proteus vulgaris, Bacillus subtilis*	6
2	*Hagenia abyssinica*	Copper nitrate	spherical	34.76	*Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus, Bacillus subtilis*	7
3	*Ocimum sanctum*	Copper sulphate	spherical	54.31	*Staphylococcus aureus, Pseudomonas aeruginosa*	8
4	*Arevalanata*	Copper sulphate	spherical	40 - 100	*Staphylococcus aureus, Escherichia coli, Bacillus cereus and Pseudomonas aeruginosa*	9
5	*Nerium oleander*	Copper sulphate	_	_	*Staphylococcus aureus, Escherichia coli, Klebsiella pneumoniae, Salmonella typhi and Bacillus subtilis*	10
6	*Heliconia psittacorum*	Copper sulphate	spherical	40 to 70	*Staphylococcus aureus, Pseudomonas putida and Escherichia coli*	11

7	*Cissus vitiginea*	Copper sulphate	spherical	10 to 20	*E. coli, Enterococcus sp., Proteus sp.,* and *Klebsiella sp.*	12
8	*Azadirachta indica*	Copper nitrate	spherical	250 to 550	*Escherichia coli and Staphylococcus aureus*	13
9	*Moringa oleifera*	Copper sulphate	spherical	35.8 to 49.2	*Escherichia coli, Klebsiella pneumoniae, Staphylococcus aureus and Enterococcus faecalis*	14
10	*Cissus arnotiana*	Copper sulphate	spherical	60 to 90	*Escherichia coli, Streptococcus sp., Rhizobium sp. & Klebsiella sp.*	15
11	*Psidium guajava*	Copper sulphate	Hexagonal, spherical& uneven	153	*Escherichia coli, Streptococcus pneumoniae*	16
12	*Ageratum houstonianum Mill*	Copper sulphate	spherical	200	*Escherichia coli*	17
13	*Parthenium hysterophorus*	Copper sulphate	spherical	1 to 100	*Bacillus subtilis, Proteus vulgaris, Staphylococcus aureus and Pseudomonas aeruginosa*	18

Table 2 Antibacterial Activity Of Copper Nanoparticles Synthesized From Fruits And Roots Of Different Plants.

S.No	Plant source	Plant part	Salt	Shape	Size	Antibacterial activity against	Reference
1	*Momordica charantia*	Fruit	Copper sulphate	Nanorods	61.4	*Staphylococcus aureus, Streptococcus mutans, Streptococcus pyogenes, Streptococcus viridans, Staphylococcus epidermidis, Corynebacterium xerosis, Bacillus cereus, Escherichia coli, Klebsiella pneumonia, Pseudomonas aeruginosa, and Proteus vulgaris*	19
2	*Corallocarbus epigaeus rizome*	Root	Copper sulphate	spherical	65 to 80	-	20
3	*1. Zingiber officinalis 2. Curcuma longa*	Root	Copper sulphate	spherical	20 to 100	*Staphylococcus aureus*	21
4	*Piper retrofractum vahl*	Fruit	Copper sulphate	spherical	2 to 10	*Escherichia coli, Staphylococcus aureus*	22

CONCLUSION

This review discloses and lists the recent literature related to copper nanoparticle synthesis from varied medicinal plant sources and their antimicrobial property by greener route. Bio-synthesized copper nanoparticles have demonstrated to hold significant anti-microbial activity against pathogenic bacteria. Hence copper nanoparticles have enormous value in nanoscience realm to treat varied diseases which may form the platform to drug discovery.

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