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Review Article

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CAESALPINIA BONDUCELLA ASSISTED GREEN SYNTHESIS OF NANOPARTICLES WITH DIFFERENT APPLICATIONS: A REVIEW

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ABSTRACT
The current study focuses on the use of *C. bonducella* extract in the production of nanoparticles of various metals such as silver, gold, phosphorus, and copper oxide. *C. bonducella* is an evergreen perennial plant of the Fabaceae family. The plant have been found to contain a variety of phytochemicals, including flavonoids, glycosides, and terpenoids. These metallic nanoparticles were assessed for one or more uses, such as antimicrobial activity. The use of *C. bonducella* polar extract revealed that its polar phytocompounds were involved in lowering the metal source and stabilising the nanoparticles. Finally, it should be highlighted that metal nanoparticles offer superior properties as compared to aqueous leaf extract.

INTRODUCTION
From conventional chemical methods to medical and environmental technologies, nanotechnology offers domains with practical applications. Nanoparticles (NPs) have made significant advances in a variety of fields, including photocatalytic organic dye-degradation activity, antioxidants and antimicrobial agents, as well as drug delivery, ointments, nanomedicine, chemical sensing, data storage, cell biology, agri-culture, cosmetics, textiles, and the food industry. NPs can be produced through physical, chemical, or green synthesis; however, synthesis using biological precursors has produced impressive results. These substances are utilized as reducing agents in the published data that is currently accessible, and the synthesized NPs are assessed using X-ray diffraction, scanning electron microscopy, and transmission electron microscopy, as well as ultraviolet-visible and Fourier-transform infrared spectra.[1]

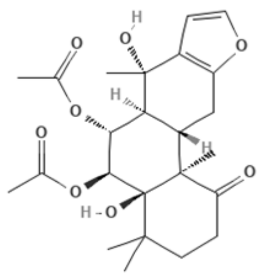
Caesalpinia bonducella L. is a huge thorny shrub, also known as 'fever nut' belongs to family caesalpiniaceae. It is found in South India, Burma and Ceylon.[2]

The seeds have been used as a styptic and to treat conditions such as helminthiasis, colic pain, malaria, hydrocele, skin disorders, and inflammation.

The oil obtained from the seeds of the plant has also been found to control bouts of convulsions and paralysis. The powdered seeds when mixed with an equal part of pepper powder and given to malarial patients were found to possess feeble antiperiodic properties. Leaves and twigs of the plant have been used traditionally to treat tumors, inflammation, liver disorders and toothache. Leaves and juices of the climber have been used traditionally to alleviate conditions such as elephantiasis and smallpox. In the West Indies, the roasted seeds have been used by the natives to treat the symptoms of diabetes.[2]

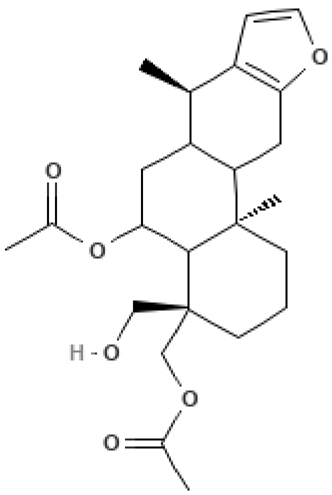
The plant is also known to possess antioxidant, atifilaria activity, anticonvulsive activity and anti-microbial activity, antimalarial activity, antitumor activity anti-ulcer activity, immunomodulatory activity and Anti-cataract activity.[2]

Seed of *C. bonducella* contains caesalpin, β-caesalpin and α- caesalpin while seed kernel contains sitosterol, heptocosane, bonducin.[2]

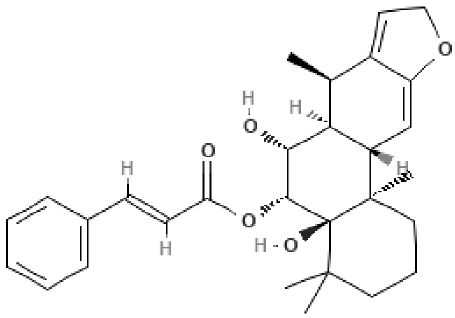


α- caesalpin

Bark was reported to contain homoisoflavonoids, caesalpinianone, 6-O-methylcaesalpinianone, hematoxylol, stereochenol A, 6'-*O*-acetylloganic acid, 4'-*O*-acetylloganic acid, 2- *O*-b-D-glucosyloxy-4-methoxybenzenepropanoic acid[3], neocaesalpin P, neocaesalpin H, cordylane A, caesalpinin B, bonducellpin E, caesalpinolide A, and 17-methylvouacapane-8,-9 –diene.[4]



cordylane A



neocaesalpin P

Huyen et al. 2022 isolated five lignans, two phloroglucinols, five flavonoids and four phenolics were identified from the leaves of *C. bonduc*.[5]

This review articles summarizes the use of different parts of *Caesalpinia bonducella* in green synthesis of nanoparticles of different metals and metal oxides, with their applications in different domains,

Synthesis of nanoparticles using seeds of *Caesalpinia bonducella*

Silver nanoparticles

Sundar et.al 2018 synthesised the silver nanoparticle using the *Caesalpinia bonducella* seed extract. They prepared the plant material extract by using the 25g sample of fresh seed powder was obtained, dissolved in 100ml of deionized water, mixed for two hours at room temperature, and then centrifuged at 10,000 rpm for ten minutes. Before centrifugation, the supernatant was gathered, kept at 0° C, and utilized to create silver nanoparticles. Further, they synthesized silver nanoparticle using the C.B. seed extract treating by 20ml of 0.1mM silver nitrate solution ($AgNo_3$). Silver ions were reduced using a silver nitrate solution, which was then incubated in the dark for 24 hours. After the 24 hours incubated indicate the change in colour of sample (Ag NP). Further, they characterized the silver nanoparticles using the UV-visible spectrum, FT-IR spectrum & TEM. Using the UV-vis spectrum was measured over the wavelength range of 200-800nm. The UV-vis spectrum measurement are recorded on Shimadzu Dual Beam Spectrometer. The Shimadzu FTIR spectrophotometer was used to measure the sample's infrared spectrum in the 4000-400 cm-1 wavelength region.

Then they screened the antimicrobial activity of silver nanoparticle against such as *Escherichia coli, Pseudomonas aeruginosa, Salmonella typhi, Shigella dysenteriae* by using the Kirby-Bauer disk diffusion method. They found the Minimum Inhibitory Concentration (MIC) test for silver nanoparticles & it is ranging between 8.7 - 9.5 mg/ml. Then, they screened the Cytotoxic potential of AgNPs agent against the Human Breast Cancer Cell (MCF-7) and found its IC50 value 78 mg/ml.[6]

Second attempt of synthesis of Silver nanoparticles was made by Prabu and Anbarasan in 2013 They synthesized Silver Nanoparticles using the medical plant *Caesalpinia bonducella* seed. They prepared the silver nanoparticles (Ag NP). Nanocomposites can be made by dissolving 50 g of *C. bonducella* Seed powder in 200 ml of Deionized water and stirring the mixture for two hours at room temperature. Then the extract was filtered and stored at 4°C for further experiments as a reducing and capping agent. The 20 ml and 0.1 mM were combined with the 4 ml of extract. 20 ml of a 10^4 m $AgNO_3$ aqueous solution and 4 ml of the extract were combined and maintained at room temperature. The colorless fluid gradually turns brown during the stirring procedure, signifying the creation of silver nanoparticles. The chemical production of sliver nanoparticle is explore and the silver nanoparticle was obtained from Sigma Aldrich Chemicals. Further, They evaluate the reduction of metallic silver nanoparticles by monitoring UV-Visible spectrometer (systronic double beam spectrometer), FT-IR spectrometer, X-Ray spectrometer, SEM & EDM analysis. Using the UV-visible spectrometer was measured the wavelength range of 200-800nm, FT-IR spectrometer wavelength range of 4000-400cm-1 region by employing std. KBr pellet techniques, SEM analysis particle size was approximately ranges of 50-300nm.[7]

In 2018, Amrin et al. synthesized the Silver nanoparticles using Seed extract of *C. bonducella*. They prepared the Analytical reagent grade $AgNO_3$ (silver nitrate), and seeds of *C. bonducella* was used to synthesis silver nanoparticle. Then, they prepared the plant material extract by using 50 ml of double-distilled water and 5gm of dried seed powder were combined, and the mixture was continually swirled at 60°C for two hours. The extract was filtered before being employed in the synthesis. Further, they silver nanoparticles using *C. bonducella* seed extract. Firstly, they synthesized silver nanoparticles 0.1 M of $AgNO_3$ was made. Drop by drop, the prepared *C. bonducella* seed extract was added to the $AgNO_3$ solution until the precipitate formed. For four hours, the solution was continually stirred. The white object turned dark brown as it was being observed. The precipitate was collected in a Petri dish, dried in the hot air oven for one day at 80°C, and then filtered using Whatman filter paper after being washed twice with double-distilled water. Further, they evaluated the silver nanoparticle by using X-ray the diffraction pattern of prepared AgNP were recorded at room temperature.[8]

Copper oxide nanoparticles

Sukumar et al. 2020 synthesized rice shaped copper oxide nanoparticles using *C. bonducella* seed extract. They prepared *C. bonducella* seed extract by using the aqueous water solvent. Due to their small size, vast surface area, chemical and optical characteristics, and good electrical conductivity, these particles are discovered to offer advantages. Further, they synthesized the copper nanoparticles by using a variety of techniques including microwave irradiation, precipitation pyrolysis and thermal decomposition. Then, they treating the extract of copper nanoparticle with Ammonia solution (25%) and 0.01M Cupric nitrate trihydrate. Further, they synthesized Copper oxide nanoparticle using the C.B. seed extract treating by ammonia solution(25%), and 0.01M cupric nitrate trihydrate were used for the synthesis. For carrying out the reduction of copper ions, 40 mL of the cupric solution was taken in a 100 mL beaker. 40 mL of the freshly obtained seed extract was then added dropwise, followed by the addition of 200 mL of ammonia solution while being constantly stirred. Over the course of five hours, the blue solution turned green. At around seven hours, a dark brown precipitate finally developed. Additionally, they characterized CuO NP using SEM, UV-visible, FT-IR, XRD, XPS techniques.

Afterward, they screened antibacterial activity properties of copper oxide Nanoparticle were investigated against *S. aureus* (Gram-positive) and *Aeromonas* (Gram positive) bacteria by the agar diffusion method and *Aeromonas* (Gram-negative) bacteria by the agar diffusion method.[9]

Phosphorus nanoparticles

Sathammai et al. 2021 synthesized a phosphorus nanoparticle using seed extract of *C. bonducella*. They prepared the *C. bonducella* seed extract using Ethanol, using which they synthesized Phosphorus Nanoparticles by about 10g of dry plant seed powder was added to 100ml of double distilled water and boiled at 50-60℃ for 10 min. The obtained extraction was filtered using Whatmann No.1 filter paper. The mixture solution could be stirred constantly at 80℃ for 6h. Then, Brown precipitate were formed on continuously stirring and nano powder was heated at 120℃. The precipitate nanoparticles were lyophilized and stored in cool, dry and dark places. Further, they characterized Phosphorus nanoparticles by UV-visible spectroscopy (200-1100nm), FTIR, XRD and SEM. By utilizing FTIR technique, the presence of functional groups in PHNPS was identified. FTIR analyzing the phosphate group at 1.077 & 1.048 cm-1. *C. bonducella* served as a potential stabilizing and reducing agent. The formation of PHNPs was first confirmed by orange colour due to the peak in the UV-Visible spectrum observed at 260 nm. They are therefore recommended as a product of value in the field of nanotechnology and nanomedicine.[10]

Synthesis of nanoparticles using leaves of *Caesalpinia bonducella*

Gold nanoparticles

Nallagouni et al. 2021 synthesized gold nanoparticle using *C. bonducella* leaf extract. By combining 5 grams of two-day air-dried leaves with distilled water to create *C. bonducella* leaf extract, which was then heated for 30 minutes, they were able to create gold nanoparticles at 40 °C with 100ml of distilled water. In a boiling tube, 5ml of leaf extract and 2ml of 1mM chloroauric acid were added. A home microwave oven was used to irradiate the reaction mixture for 4 minutes at a power of 300W at a frequency of 2.45GHz. A shift in colour showed that gold nanoparticles had formed. Further, they evaluated gold nanoparticle by using UV-visible spectroscopy (3600,Shimadzu), FT-IR spectra(IR-affinity), X-ray diffraction (Rigaku miniflex) and TEM(Jeol,2000 FX-II TEM) techniques. Afterword they screened anti-microbial activity of Gold Nanoparticles against both Gram positive and Gram negative bacteria by using Disc diffusion method. They found the surface Plasmon resonance of the nanoparticles was seen around 518–538 nm.The XRD analyses revealed that the Gold nanoparticles are crystalline in form and have a face-centered cubic structure. The production and stability of gold nanoparticles were demonstrated by FTIR analysis to involve both carbonyl and hydroxyl groups.TEM pictures demonstrated the gold nanoparticles' spherical form and nano-regime size. Both Gram-positive and Gram-negative bacteria were susceptible to the antibacterial effects of these Gold nanoparticles. The results of this work suggest that greenly produced Gold nanoparticles may be effective and promising antibacterial agents.[11]

Synthesis of nanoparticles using stem bark of *Caesalpinia bonducella*

Silver nanoparticles

Rao and Rao, 2016 synthesized the silver nanoparticles using *Caesalpinia bonduc* stem bark extract. They prepared *C. bonduc* stem bark extract by using Q water. The material was then further cooked in a conical flask for 15 to 20 minutes. For a subsequent experiment, obtained stem bark extract was filtered through Whatmann's filter paper no.1 and kept in a refrigerator at 4°C. Then, they synthesized the AgNP using Silver nitrate ($AgNO_3$) was purchased from Sigma Aldrich, and a solution containing 1 mM $AgNO_3$ was made, kept in an amber-colored vial, and utilised in subsequent experiments. With steady stirring, 10 ml of plant material broth was added to 90 ml of 1 mM aqueous silver nitrate, and the mixture was left to react at room temperature for Ag+ ion reduction. The creation of silver nanoparticles from the stem bark extract of *C. bonduc* is indicated by the reaction mixture's apparent colour change from translucent yellow to dark brown. Further, they evaluated the Silver nanoparticle by ELICO SL-159 UV-Vis spectrophotometer, FTIR spectroscopy analysis (Bruker α- spectrophotometer). Then the morphology of AgNP was determined by the SEM in Zeiss 700 and TEM was used for characterised size and shape of AgNP in Philips model CM 200 instrument. Then, they screened the antimicrobial activity of silver nanoparticle against the both gram positive bacteria (*Staphylococcus aureu*, *Basillus subtilis*) and Gram negative bacteria (*Escherichia coli*) by using Disc Diffusion Assay Method.[12]

CONCLUSION

Metal and metal oxide nanoparticles have several scientifically verified applications in a variety of disciplines. To overcome the environmental challenges posed by chemical methods (which use hazardous chemicals) and the requirement of large, expensive machineries in physical methods of nanoparticle fabrication, an eco-friendly approach involving the use of plant extracts for green synthesis of various nanoparticles has been developed.

The leaves, seeds and stem bark of *C. bonducella* include a variety of phytochemicals that are made available for the reduction of donor compounds to corresponding nanoparticles by solvent extraction. Based on this review, it can be concluded that *C. bonducella* extracts, due to the presence of few polar phytoconstituents, can be used for green synthesis of nanoparticles of different metals (silver and gold) and metal oxides (phosphorus and copper oxide) with a wide range of applications in various scientific domains, including antimicrobial and anti-cancer activities.

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