ORIGINAL ARTICLE

Characterization and antimicrobial activity of cerium oxide nanoparticles synthesized using neem and ginger

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ABSTRACT

The aim of this study is to analyze and characterize the antimicrobial effect of cerium oxide nanoparticles (NP) synthesized using neem and ginger. Finely grounded neem and ginger powder were taken and mixed with distilled water. This mixture was then heated and filtered. Ammonium cerium nitrate dissolved in distilled water. Both the mixtures were mixed and stirred magnetically. A double-beam ultraviolet-visible spectrophotometer was used to monitor color changes. The extract was centrifuged at 8000 rpm for 15 min. The final pellet was powdered using a hot air oven at 70°C for 24 h. Visualization was done by transmission electron microscopy and spherical morphology was noted, with an average diameter of 5 nm, in aggregated form. The sample containing 100 mg of cerium oxide shows the most significant effect on the zone of inhibition of 11 mm of *Staphylococcus aureus*. The results obtained in the current study confirmed that CeO-NP possessed antioxidant and cytotoxic properties.

Key words: Cerium, characterization, ginger, innovative, nanoparticles, neem

INTRODUCTION

Nanoscience and nanotechnology are emerging fields these days.[1] Nanotechnology involves materials that are made on a nanometer scale to gain characteristics and perform functions which cannot be achieved in another way.[2] The dimensions of the materials vary between 1 and 100 nanometers.[3] Optical absorption, electronic conductivity, chemical reactivity, and biocompatibility are some of the properties that undergo significant changes in nano-dimensions, in comparison with the macro-dimensions of the same material.[4]

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The surface area and the number of atoms present on the surface increase extraordinarily, with the reduction in particle size, leading to a change in surface properties.[5,6] Nanotechnology currently remains in a preliminary phase ranging from basic research to industrial practice.[7] Further research in nanotechnology will benefit multiple industries.[7,8]

Cerium belongs to the lanthanide series and is a rare earth element. The crust of the earth is rich in this element, being the most abundant from the lanthanides, in spite of it being a rare earth material.[9-11] The ceria nanoparticles (NP), with their distinct structure, scavenge free radicals, thereby leading to cell longevity.[12,13] The coexistence of two oxidation states in cerium oxide NP greatly influences their antioxidant behavior.[14,15]

These NP can be used as antioxidants as well as antimicrobials. Cancer and metabolic syndrome are

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excessive reactive oxygen species diseases which can be treated.[16] The world is currently faced with multiple microorganisms that are multidrug resistant, which can be addressed by antimicrobial nature.[16-18]

The antimicrobial activity of neem and ginger is well researched and documented. The factors affecting the antimicrobial activity of a compound are composition, extraction method, volume of inoculum, concentration of the extract, type of pH media used, and the growth phase of the organism.[19]

Our research and knowledge have resulted in high-quality publications from our team.[20-38] Thus, the aim of this study is to analyze and characterize the antimicrobial effect of cerium oxide NP synthesized using neem and ginger.

MATERIALS AND METHODS

Preparation of neem and ginger extract

Finely grounded neem powder 0.5 g and ginger powder 0.5 g were taken and added to 100 mL of distilled water. This was then heated at 60°–80°C for 10 min. Once boiled, filtration of the mixture was done. The filtrate was then sealed and placed in the refrigerator [Figures 1 and 2].

Preparation of cerium nanoparticle

About 0.274 g of ammonium cerium nitrate was weighed and then dissolved in 70 mL of distilled water. To this, 30 mL of filtered neem and ginger extract was incorporated. The final mixture was stirred magnetically for 2–3 days at 650–800 rpm. Uniform dispersion was thus obtained, which is a nanoparticle synthesis prerequisite. A double-beam ultraviolet-visible (UV-vis) spectrophotometer was used to detect color changes in the mixture. The final mixture was then centrifuged for 15 min at 8000 rpm. The obtained cerium oxide NP was then powdered at 70°C for 24 h in a hot air oven. It was preserved in an airtight vial to prevent contamination [Figure 3].

Characterization of cerium nanoparticles

UV-vis spectrophotometer was used to measure the maximum absorbance of neem and ginger-mediated cerium oxide NP. The transmission electron microscopy analyzed the size and shape. The result showed that the CeO-NPs were spherical, and the average diameter was about 5 nm. They were also in aggregated form to some extent. Fourier-transform infrared spectroscopy analysis was done to identify the functional groups. Elemental analysis was done using an energy-dispersive X-ray detector.

Antimicrobial activity

Streptococcus mutans, *Staphylococcus aureus*, *Enterococcus faecalis*, and *Candida albicans* were the oral pathogens used to test the antimicrobial activity in this study, by measuring the zone of inhibition (ZI). Mueller–Hinton agar was used. The plates were prepared and sterilized for 45 min at 120 lbs. The media was then poured into the sterilized plates. It was then left stable for solidification. The wells were cut and swabbing was done with the test organisms. Cerium oxide NP of various concentrations was loaded. Incubation was done at 37°C for 24 h. The ZI was measured after the incubation time.

RESULTS

Antimicrobial activity

Cerium oxide samples of different concentrations (25, 50, and 100 mg of cerium oxide) were used to study the antimicrobial properties of cerium oxide. The sample containing 100 mg of Cerium oxide shows the most significant effect on the ZI of 11 mm of *S. aureus*. All the samples show a similar ZI of 9 mm for antimicrobial activity in all concentrations of cerium oxide NP. The green synthesized CeO-NPs showed significant antibacterial activity against Gram-positive bacteria (GPB) and Gram-negative bacteria (GNB). In addition, the antibody reaction was highest against *E. faecalis* at 40 mm. This was followed by *S. mutans*, *S. aureus,* and *C. albicans* at 28 mm, 22 mm, and 10 mm, respectively [Figures 4-8 and Table 1].

Figure 1: Prepared neem and ginger extract

Figure 2: Filtrate

DISCUSSION

The present study was done to explore the utility of NPs as a potential antibacterial agent. Since NP have less toxicity and are more heat resistant, they have multiple biological applications. Three different concentrations of cerium oxide samples were used in this study (25, 50, and 100 mg of cerium oxide). The sample containing 100 mg of cerium oxide shows the most significant effect on the ZI of 11 mm of *S. aureus*. All the samples show a similar ZI of 9 mm for antimicrobial activity in all concentrations of cerium oxide NP. The green synthesized CeO-NPs tested in antibacterial activity showed a significant effect on GPB and GNB. In addition, the antibody reaction was highest against *E. faecalis* at 40 mm. This was followed by *S. mutans*, *S. aureus*, and *C. albicans* at 28 mm, 22 mm, and 10 mm, respectively.

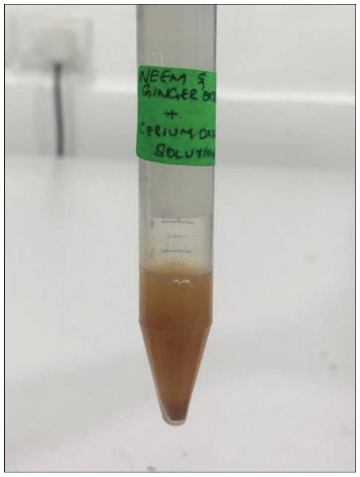

Figure 3: Pellet and supernatant after centrifuge

Figure 4: Disc diffusion for *Streptococcus mutans*

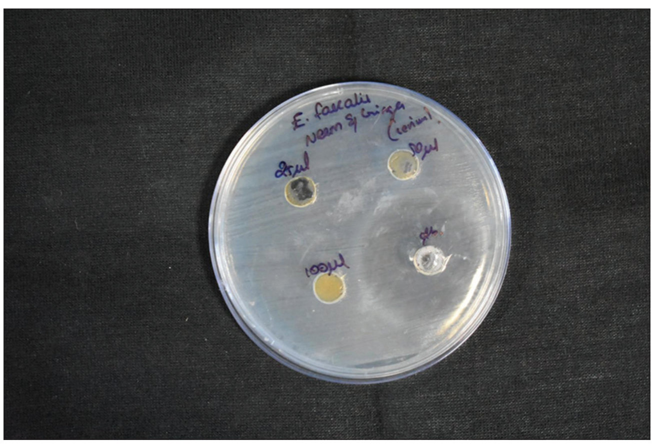

Figure 5: Disc diffusion for *Enterococcus faecalis*

Figure 6: Disc diffusion for *Staphylococcus aureus*

Figure 7: Disc diffusion for *Candida albicans*

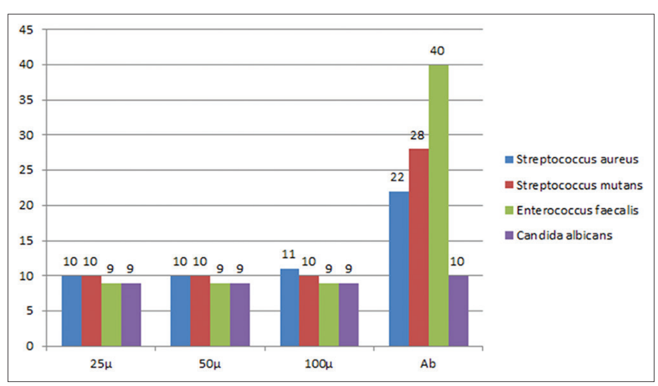

Figure 8: Figure depicting the zone of inhibition of Gram-positive and Gram-negative bacteria for various concentrations of cerium oxide nanoparticles

Table 1: The zone of inhibition (mm) of Gram-positive and Gram-negative bacteria for various concentrations of cerium oxide nanoparticles

	25 mg	50 mg	10 mg	Antibody
Staphylococcus aureus	10	10	11	22
Streptococcus mutans	10	10	10	25
Enterococcus faecalis	9	9	9	40
Candida albicans	9	9	9	10

One study used a green method for the synthesis of CeO-NP using marjoram leaf extract.[39] A study on adult rat spinal cord neurons demonstrated the antioxidant and neuroprotective effect of CeO-NP.[40] The anti-inflammatory activity of this NP was similar to nitric oxide free radicals scavenging activity.[41] Fibroblasts of the skin were used to test the protective effects of these NPs and it was seen that the viability of the fibroblasts was not affected by exposure.[42] The results of this study were similar to those obtained from an antioxidant evaluation test where the synthesized CeO-NP protected the cells from oxidant-mediated apoptosis by preserving the antioxidant defense system of the cells.[43,44]

CONCLUSION

The cerium NP synthesized using neem and ginger extract by green method possessed both antioxidant and cytotoxic properties.

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Conflicts of interest

There are no conflicts of interest.

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