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Awareness About Medicinal Application Of Cerium Oxide Nanoparticles Among Dental Students

Research Article

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Abstract

Introduction: Cerium Oxide (CeO2) NPs, among other NPs, have been widely used because to their unique surface chemistry, high stability, and biocompatibility. Sensors, cells, catalysis, therapeutics agents, drug delivery careers, and anti-parasitic ointments are all made with it. Antimicrobial, anti-cancer, anti-larvicidal, photo-catalysis, and antioxidant therapies have all been documented so far using green produced CeO2 NPs.
Aim: This survey was conducted for assessing the awareness about medicinal application of Cerium oxide nanoparticles amongst dental students.
Materials and Method: A cross-section research was conducted with a self-administered questionnaire containing ten questions distributed amongst 100 dental students. The questionnaire assessed the awareness about Cerium oxide nanoparticles therapy in medical applications, their anti-oxidant properties, anti-bacterial properties applications, anti-neurodegenerative properties applications, enzyme mimicking properties and biosensing properties. The responses were recorded and analysed.
Results: 23% of the respondents were aware of the medicinal applications of Cerium oxide nanoparticles. 19 % were aware of anti-oxidant properties of Cerium oxide nanoparticles, 17 % were aware of anti-bacterial properties of Cerium oxide nanoparticles, 15 % were aware of anti-neurodegenerative properties of Cerium oxide nanoparticles, 14% were aware of enzyme mimicking properties of Cerium oxide nanoparticles and, 10 % were aware of biosensing properties of Cerium oxide nanoparticles.
Conclusion: There is limited awareness amongst dental students about use of Cerium oxide nanoparticles therapy in medical applications. Enhanced awareness initiatives and dental educational programmes together with increased importance for curriculum improvements that further promote knowledge and awareness of Cerium oxide nanoparticles therapy.

Keywords: Awareness; Cerium Oxide; Nanoparticles; Students; Medicinal.

Introduction

Nanotechnology has sparked widespread interest in every aspect of science and technology, and it is now regarded as one of the most promising study areas. It can be used in a variety of fields, including electronics, imaging, industry, and healthcare. It has mostly been used in healthcare for illness diagnosis, therapy, delivery, and formulations of innovative medications. It makes use of nanoparticles, which are small structures with a size range of 1–100 nm (NPs). These nanoscale entities have unique physicochemical features and have been used in physics, biology, and chemistry research [1].

Cerium Oxide (CeO2) NPs, among other NPs, have been widely used because to their unique surface chemistry, high stability, and biocompatibility. Sensors, cells, catalysis, therapeutics agents, drug delivery careers, and anti-parasitic ointments are all made with it. Antimicrobial, anti-cancer, anti-larvicidal, photo-catalysis, and antioxidant therapies have all been documented so far using green produced CeO2 NPs [2]. Antimicrobial potential is undoubtedly the most exploited among other biomedical applications. CeO2 NPs have previously been shown to have antimicrobial properties via a variety of ways. CeO2 NPs, on the other hand, destroy microorganisms by causing an overabundance of reactive oxygen

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species in cells. However, more research is needed to completely understand the precise mechanism of action [3, 4]. Our research experience has prompted us in pursuing this research [5-16]. This survey was conducted for assessing the awareness about medicinal application of Cerium oxide nanoparticles amongst dental students.

Materials and Methods

A cross-section research was conducted with a self-administered questionnaire containing ten questions distributed amongst 100 dental students. The questionnaire assessed the awareness about Cerium oxide nanoparticles therapy in medical applications, their anti-oxidant properties, anti-bacterial properties applications, anti-neurodegenerative properties applications, enzyme mimicking properties and biosensing properties. The responses were recorded and analysed.

Results

23% of the respondents were aware of the medicinal applications of Cerium oxide nanoparticles (Fig 1). 19 % were aware of anti-oxidant properties of Cerium oxide nanoparticles (Fig 2), 17 % were aware of anti-bacterial properties of Cerium oxide nanoparticles (Fig 3), 15 % were aware of anti-neurodegenerative properties of Cerium oxide nanoparticles (Fig 4), 14% were aware of enzyme mimicking properties of Cerium oxide nanoparticles (Fig 5) and, 10 % were aware of biosensing properties of Cerium oxide nanoparticles (Fig 6).

Discussion

The unique property of CeO2-NPs that makes them distinct from other antioxidants is their ability to self-regenerate their surface. Thus, one small dose can work for a long time before being cleared from the body.7 Accordingly, various kinds of CeO2-NPs have been synthesized in order to target the Achilles' heel of any oxidative stress-associated diseases. Investigating previous literature on ceria NPs demonstrated that different synthesis methods could provide cerium oxide NPs with various catalytic and physicochemical properties that could contribute to antioxidant or prooxidant properties [17].

Figure 1. Awareness of the medicinal applications of Cerium oxide nanoparticles.

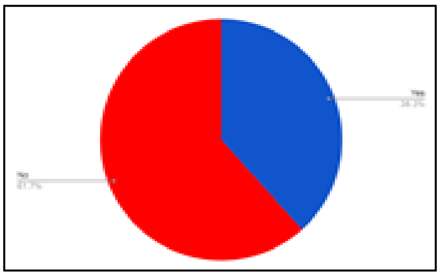


Figure 2. Awareness of the anti-oxidant properties of Cerium oxide nanoparticles.

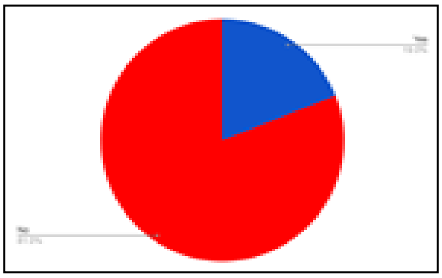


Figure 3. Awareness of anti-bacterial properties of Cerium oxide nanoparticles.

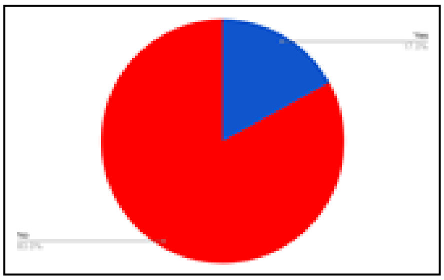


Figure 4. Awareness of anti-neurodegenerative properties of Cerium oxide nanoparticles.

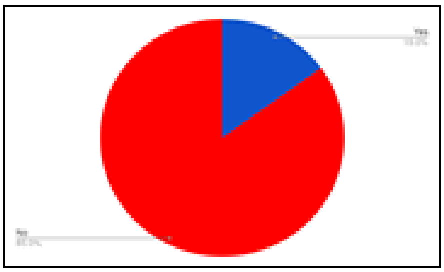


Figure 5. Awareness of enzyme mimicking properties of Cerium oxide nanoparticles.

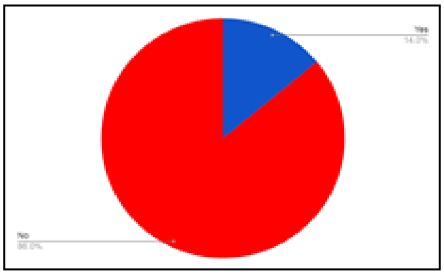
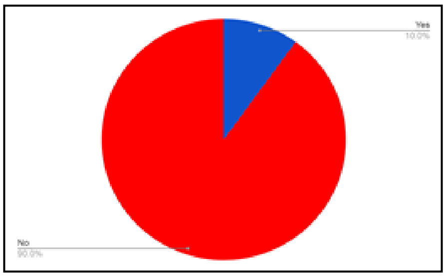


Figure 6. Awareness of biosensing properties of Cerium oxide nanoparticles.



Energy-dependent, clathrin-mediated, and caveolae-mediated endocytic mechanisms allow CeO2-NP to enter cells. Singh et al. discovered it in mitochondria, lysosomes, and the endoplasmic reticulum, as well as the cytoplasm and nucleus. Given cerium oxide's radical-scavenging characteristics and extensive cellular distribution, a CeO2-NP is anticipated to operate as a cellular antioxidant in different compartments of the cell, providing protection from a variety of oxidant injuries [18].

Several studies have reported CeO2-NPs' antibacterial activity and demonstrated their considerable suppression of both gram-negative and gram-positive bacteria. CeO2-NPs with particle sizes greater than 20 nm are thought to have antibacterial characteristics [19, 20]. Furthermore, the antibacterial effects of the highest percentage of surface Ce3+ of NP are consistent with many observations [21].

CeO2-NP therapy, which removes or prevents ROS generation and impacts different important locations in brain cells or central nervous tissue, is a useful therapy for neurodegenerative illnesses. CeO2-NPs have been shown to alter directly or indirectly, the signal transduction pathways involved in neuronal death and neuroprotection by reducing ROS generation. Cerium oxide NPs, for example, have been shown to activate neuronal survival in a human Alzheimer's disease model via altering the brain-derived neurotrophic factor (BDNF) pathway. BDNF is a protein that plays a role in neuronal survival signaling pathways [22].

CeO2-NPs have a unique feature that could cause angiogenesis in vivo. Angiogenesis is the physiological process by which pre-existing blood vessels give rise to new ones. CeO2-NPs, in particular, cause angiogenesis via altering gene regulation by modifying the intracellular oxygen environment and endogenously stabilising hypoxia inducing factor 1. CeO2-NPs are also more catalytically active in regulating intracellular oxygen because of their high surface area, higher Ce3+/Ce4+ ratio, and tiny size, which leads to a more robust induction of angiogenesis [23].

CeO2-NPs have been used to create a variety of biosensors, including electrochemical, fluorometric, and colorimetric sensors, which are briefly addressed here. For the first time, the catalytic activity of cerium oxide NP was used to create a very sensitive biosensor. Synthesized electrochemical biosensors based on cerium oxide NPs were found to be effective tools for detecting H2O2 in as little as 1 mM of water in a study [24]. Interfacing H2O2 with inorganic NPs has resulted in the production of a number of nanozymes with catalase or peroxidase-like activity. *Liu et al.,* recently published a fluorometric sensing device based on DNA/CeO2-NP for very sensitive detection of H2O2 [25].

CeO2-NPs are forms of powerful artificial oxidase enzymes capable of mimicking catalase and SOD and peroxidase-like activities Tian *et al.,* used a nanostructure-based enzyme-linked immunosorbent test to take advantage of CeO2-NPs' peroxidase-like activity for breast cancer cell identification (ELISA). 2 The primary antibody against a breast cancer biomarker (CA15-3) was coated on the ELISA plate in the developed system, and the second antibody was directly attached on the surface of CeO2-NPs via electrostatic forces. When cancer cells are present, the primary antibody can capture them, and the secondary antibody-conjugated CeO2-NPs can connect to them, causing H2O2 oxidation and colour change [26].

Pirmohamed *et al.,* gave the first study on CeO2-NPs' catalase mimicking activity [27]. CeO2-NPs' catalytic activity has recently been used in a variety of biomedical applications. Akhtar *et al.,* found that CeO2-NPs' catalase activity increased intracellular glutathione (GSH) in cells challenged with H2O2, shielding cells from oxidative damage [28]. Given the importance of GSH in cell growth and division, carcinogen metabolism, and DNA protection from oxidative damage, CeO2-NPs' ability to increase intracellular GSH levels is a major breakthrough in medical biology. Ceria was examined for its superoxide dismutase-like activity, and researchers produced a stable and biocompatible artificial enzyme system based on CeO2-NPs that had strong ROS scavenging activity over time. They created a biocompatible CeO2-NP encapsulated ceria-albumin nanoparticle (BCNP) capable of decreasing intracellular ROS. The BCNPs protected the cells from oxidant-mediated apoptosis by preserving their antioxidant defence mechanism [29].

Conclusion

There is limited awareness amongst dental students about use of Cerium oxide nanoparticles therapy in medical applications. Enhanced awareness initiatives and dental educational programmes together with increased importance for curriculum improvements that further promote knowledge and awareness of Cerium oxide nanoparticles therapy.

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