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Synthesis of nanostructured CeO_2 by chemical and biogenic methods: Optical properties and bioactivity

Angel Rose Rajan[a], Vidya Vilas[b], Anish Rajan[c], Annamma John[a], Daizy Philip[a,*]

[a] Department of Physics, Mar Ivanios College, Research Centre, University of Kerala, Thiruvananthapuram, 695015, India
[b] Department of Science and Humanities, Mar Baselios College of Engineering and Technology, Thiruvananthapuram, 695015, India
[c] Department of Physics, St.Stephen's College, Pathanapuram, 689695, India

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ABSTRACT

Synthesis of nanostructured CeO_2 by chemical and biological methods has been performed. Oxalic acid and polyethylene glycol have been utilized for the chemical synthesis, while, *Simarouba glauca* leaf extract is used for the synthesis of biogenic CeO_2 nanoparticles. The synthesized nanoparticles have been characterized using UV–visible, PL, XRD, TEM, EDAX, FTIR and Raman techniques. TG-DTG analysis has revealed an annealing temperature above 420 °C to be suitable for the complete conversion of the synthesized materials into nanostructured CeO_2 NPs. UV–visible spectra give band gap energies of 3.41, 3.65 and 3.81eV for the synthesized bare, polymer capped and biogenic nanostructures, respectively. Biogenic nanoparticles show a striking average particle size of ≈9.9 nm imparting them superior optical and bioactivities in comparison to the other samples. Intensity of PL emission peak at 467 nm arising due to the charge transfer from the 4f conduction band to the 2p valence band of CeO_2 is found to increase with a decrease of particle size depicting better crystallinity of the biogenic sample. Particle sizes calculated from Raman line broadening at 461 cm^{-1} representing F_{2g} mode of cubic fluorite structured CeO_2 are found to coincide with those from XRD and TEM. The bio fabricated CeO_2 NPs at the concentration of 100 μg/mL shows significant bactericidal activity against *E. coli* and *S. aureus* due to the direct interaction of CeO_2 NPs on the membrane surface of the microorganisms. The biogenic CeO_2 NPs exhibited prominent wound healing activity on L929 fibroblast cell line in comparison with the control. Further, complete wound healing has been observed for cells treated with all the synthesized samples after 24 h. The simple, cost-effective and eco-friendly biogenic method for the synthesis of nanostructured CeO_2 exposes superior properties enabling their utilization in biomedical field.

1. Introduction

Nanomaterials exhibit extraordinary optical, magnetic, electrical, thermal, and mechanical properties compared to their bulk counterparts [1]. Among these materials, nanostructured CeO_2 (nanoceria) has gained substantial attention in the scientific world owing to their unique size and shape dependent physico-chemical properties. Different synthesis techniques such as flame spray pyrolysis, sol-gel, micro emulsion methods, thermal decomposition, and microwave assisted solvothermal process have been used to fabricate cerium oxide (CeO_2) nanoparticles (NPs) [2]. CeO_2, a semiconductor with wide band gap energy is considered as an important rare earth metal oxide, extensively used as a potent oxidation catalyst, UV blocker, in fuel cell, absorbent for water treatment and CO oxidation due to its optimum mechanical strength, redox potential, optical property and high oxygen storage capacity [3]. The crystalline nanoceria show enhanced electronic, optical and structural properties due to increased surface to volume ratio and quantum confinement effect [4].

A thorough literature survey highlights the importance of CeO_2 NPs in biomedical fields. Nanostructured CeO_2 has been reported to have antimicrobial property against the Gram-negative bacteria, *Escherichia coli* (*E.coli*) and the Gram-positive bacteria, *Staphylococcus aureus* (*S.aureus*). The antibacterial potency of nanoceria generally depends on their size, morphology and specific surface area, which contribute positively towards killing bacterial pathogens [5]. Nanomaterials possessing bactericidal properties, however, with less toxicity to normal cells have become a potential area of research. A wound is a breakdown in the protective function of the skin, the loss of continuity of epithelium, along with or without loss of underlying connective tissues including muscle, bone and nerves [6]. Nanoceria support nominal toxicity to

* Corresponding author.
E-mail address: daizyp@rediffmail.com (D. Philip).

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