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Synthesis of CeO_2 nanostructures with its exceptional biological and chemocatalytic activities: a comparative study

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Abstract. A comparative study has been carried out on the synthesis of nanostructured CeO_2 through chemical and biological methods. CeO_2 nanoparticles have been synthesized chemically using oxalic acid. The as-synthesized nanoparticles have been stabilized using the capping agent, polyvinylpyrrolidone. The aqueous leaf extract of *Annona reticulata* has been utilized for the biofabrication of CeO_2 nanoparticles. XRD, TEM and Raman analyses have been carried out to determine the structure and formation of the as-synthesized products. Optical studies have been carried out through UV–visible absorption, photoluminescence, Fourier transform infrared and Raman spectroscopic techniques. The biosynthesized CeO_2 nanoparticles exhibit strong antioxidant activity as well as potent antidiabetic and wound healing activities in comparison to their chemically fabricated counterparts, extending the possibility for their application in pharmaceuticals. The biogenic nanoparticles also exhibit superior catalytic activity in the degradation of harmful dyes including methylene blue and eosin yellowish.

Keywords. Cerium oxide nanoparticles; *Annona reticulata*; antidiabetic activity; wound healing activity; catalytic activity.

1. Introduction

CeO_2 is a unique rare-earth metal oxide possessing distinctive physicochemical properties and has applications in numerous fields including fuel oxidation catalysis, semiconductor industry, hydrogen production and gas sensing [1,2]. The cubic fluorite structured CeO_2 has very high chemical and thermal stability even at high temperatures. Nanostructured CeO_2 with varying morphology have been fabricated and characterized by different techniques [3–5]. Among the chemical processes, precipitation method is very easy, inexpensive and time-saving in comparison to other synthetic routes [6]. Pinjari and Pandit [4] have synthesized nano ceria powders using sodium hydroxide as the precipitating agent. Nanocrystals <30 nm could be synthesized through this method. In yet another work, Farahmandjou *et al* [6] have synthesized cerium oxide nanoparticles (CeO_2 NPs) using cerium nitrate and potassium carbonate precursors through a coprecipitation method. Face-centred cubic crystalline structure nanoparticles (NPs) of around 9 nm have been synthesized by Shirke *et al* [3] using cerium nitrate, propylene glycol and ammonia as the precursors.

Recently, phytogenic CeO_2 NPs synthesis protocols that use natural materials as reducing and capping agents have gained great importance due to their capacity to fabricate biocompatible materials [7,8]. In the context of non-availability of a clearance mechanism for cerium or its oxides from the biosystems, their biocompatibility or rather benign nature is of utmost importance. This shall be attained mostly through a phytosynthetic protocol. A stable, 3.9 nm sized nano ceria have been synthesized by Thovhogi *et al* [9] using *Hibiscus sabdariffa*'s flower aqueous extract. Maqbool *et al* [10] have successfully synthesized bioactive CeO_2 NPs using *Olea europaea* leaf extract. Leaf extracts of *Gloriosa superba* L. and *Acalypha indica* have been utilized by Arumugam *et al* [11] and Kannan and Sundrarajan [12], respectively, to synthesize CeO_2 NPs with potential antibacterial activity.

The lanthanide exists in its +3 and +4 oxidation states on the surface of the nano oxide. The ability to switch over between the two oxidation states instills in it potential catalytic and bioactivities. The pharmaceutical properties of CeO_2 NPs earmark them for use as potent drug delivery and biomedical agents [13,14]. Hegazy *et al* [13] have

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