

THERMODYNAMIC STUDY OF CERIUM OXIDE NANOPARTICLES AND THEIR EFFECTS ON CELLULAR METABOLISM

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DOI: https://doi.org/10.34107/ LWWJ5713195

ABSTRACT

Oxidative stress is associated with a large range of health conditions. It is caused by the accumulation of reactive oxidative species above cellular neutralization capability. Cells generally defend against oxidative stress with ROS decomposing enzymes such as superoxide dismutase and catalase. Cerium oxide nanoparticles display activity that mimics superoxide dismutase and catalase antioxidative properties, allowing them to combat oxidative stress. Oxidative stress can impair the mitochondrial function and energy output of cells, which can be measured as heat with closed ampoule isothermal microcalorimetry. Thermodynamic analysis of the cell's response to nanoceria treatment can help improve understanding of its general medical applications. Murine macrophages of the RAW264.7 cell line were cultured in 10% FBS supplemented DMEM media with 1% AA until it reached 90-95% confluency monitored by the EVOS M5000 microscope. After establishing a baseline heat output for healthy cells using a TAM-III isothermal microcalorimeter, the heat flow was measured in cells under induced oxidative stress. MTT assay was performed with various concentrations of nanoceria to identify the optimal dosage at which its antioxidative properties are most effective. In this study, we described the effect of nanoceria on mitochondrial activity.

Keywords: Oxidative Stress, ROS, Nanoceria, Microcalorimetry, Antioxidants, LPS, MTT

INTRODUCTION

Antioxidative properties of cerium oxide nanoparticles (nanoceria) display properties similar to those of neutralization enzymes that combat reactive oxygen species (ROS) and reactive nitrogen species (RNS). These neutralization enzymes include superoxide dismutase and catalase, both of which are used to combat oxidative stress within cells. Cerium oxide nanoparticles can switch between Ce^{3+} and Ce^{4+} oxidation states, resulting in impressive oxygen storage [6]. Reactive species exist in cells naturally and serve regulatory functions. The excess of reactive species is the cause to many modern health issues. Oxidative stress occurs when ROS and RNS accumulate, and the cell cannot remove them via neutralization enzymes. Health conditions such as cardiovascular disease, cancers, and neurological disorders have been linked to oxidative stress. Using nanoceria's antioxidative properties to aid cellular enzymes to combat these reactive species could prove useful to preventing and treating these diseases. Most ROS and RNS are generated via mitochondrial metabolism and result in trace heat production. We hypothesized that oxidative stress leads to increased metabolic activity which can be measured as heat flow through microcalorimetry.