論文 / 著書情報
Article / Book Information

題目(和文)	液体中でのレーザーアブレーションにより作製されたCeO2ナノ粒子とその光学的および電気化学的特性に関する研究
Title(English)	Study on CeO2 Nanoparticles Prepared by Laser Ablation in Liquid and their Optical and Electrochemical Properties
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Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	応用化学 ライフエンジニアリング	系 コース	申請学位（専攻）： Academic Degree Requested	博士 Doctor of (Philosophy)
学生氏名： Student's Name	Shi Mengqi		審査員主査： Chief Examiner	和田　裕之

要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

This dissertation delves into the innovative synthesis of CeO_2 nanoparticles via laser ablation and thoroughly investigates their optical and electrical properties, with a particular focus on enhancing their applications in UV protection and biosensors. It meticulously compares the laser ablation in liquid (LAL) method with traditional synthesis techniques and evaluates the electrochemical performance of CeO_2-based composites, providing significant insights into the potential advancements in these fields.

Chapter 1: General Introduction
This chapter sets the stage by introducing CeO2 nanoparticles, highlighting their unique structure and diverse applications. It discusses the critical role of oxygen vacancies in influencing the optical properties and electrode sensitivity of CeO2. The laser ablation in liquid (LAL) method is presented as a revolutionary synthesis technique that surpasses traditional methods in producing high-quality nanoparticles. The objectives are clearly defined, focusing on optimizing the synthesis process and enhancing the practical applications of CeO2 nanoparticles in UV protection and biosensors.

Chapter 2: Experiment
This chapter provides a detailed account of the experimental procedures used in the study. It covers the preparation of CeO_2 suspensions and the intricate setup for the LAL method. Comprehensive descriptions of various characterization techniques, including X-ray Powder Diffraction (XRD), Scanning Electron Microscopy (SEM), Dynamic Light Scattering (DLS), Ultraviolet-Visible Spectroscopy (UV-vis), Energy-Dispersive X-ray Spectroscopy (EDS), and Cyclic Voltammetry (CV), are provided. These techniques are crucial for thoroughly analyzing the synthesized nanoparticles' properties, ensuring accuracy and reliability in the research findings.

Chapter 3: Effect of Laser Fluence on CeO_2 Morphology and Optical Properties
This chapter examines the profound impact of laser fluence on the morphology and optical properties of CeO_2 nanoparticles. It begins with an in-depth introduction to UV radiation and its diverse effects. The chapter then details the experiments conducted under varying conditions of suspension concentration, irradiation duration, and laser fluence.
Phase Analysis: X-ray diffraction patterns confirm that the synthesized CeO_2 nanoparticles retain their cubic fluorite structure without impurities, regardless of laser fluence.
Morphology of CeO_2 NPs: SEM images reveal that higher laser fluence produces smaller, more spherical nanoparticles. The DLS patterns show an increase in secondary particle size with higher fluence, indicating better aggregation and uniformity.
Discussion of Aggregation Phenomenon: The chapter discusses how prolonged irradiation and higher particle concentrations lead to the formation of secondary particles through aggregation. This is due to the high surface energy and the tendency of nanoparticles to minimize this energy by forming larger, stable particles.

Chapter 4: Effect of focused laser ablation on NPs production and the morphology comparison
This chapter presents a rigorous comparative analysis of the LAL method and the traditional precipitation method for synthesizing CeO_2 nanoparticles. It meticulously describes the experimental procedures for both methods and evaluates their efficiency and the quality of the nanoparticles produced.

Experimental Procedures: Detailed descriptions of the laser ablation setup and the precipitation method are provided, including the preparation of CeO_2 suspensions and tablets for ablation.
Results and Discussion: The LAL method is shown to produce nanoparticles with superior control over size and shape, achieving higher purity and uniformity compared to the precipitation method. SEM and other characterization techniques reveal that the LAL method minimizes contamination and allows for precise control over nanoparticle morphology.
Advanced Data Analysis: The use of data science techniques to analyze SEM images and quantify nanoparticle concentration post-filtration underscores the LAL method's advantages. The chapter highlights how this method produces environmentally friendly conditions, making it a superior choice for nanoparticle synthesis.

Chapter 5: Electrochemical Properties of CeO_2 NPs in Modifying the rGO-GCE Electrode
This chapter focuses on the innovative application of CeO_2 nanoparticles in enhancing the sensitivity of electrochemical sensors. It discusses the modification of graphene oxide to reduced graphene oxide (rGO) and the meticulous preparation of CeO2-rGO nanocomposites.
Preparation of CeO_2-rGO Nanocomposites: The chapter details the synthesis process, including the transformation of graphene oxide to rGO and the uniform doping of CeO_2, resulting in a synergistic composite material.
Electrochemical Analysis: Using cyclic voltammetry, the electrochemical properties of the modified glassy carbon electrode (GCE) are evaluated. The results show that the CeO_2-rGO composite significantly enhances the sensitivity and selectivity of the electrode for detecting ammonia.
Applications: The improved performance of the CeO_2-rGO composite electrode has significant implications for biomedical diagnostics and environmental monitoring. The chapter emphasizes the practical applications of this enhanced sensor technology, highlighting its potential to provide more accurate and reliable measurements in various fields.

Chapter 6: General Conclusion
The concluding chapter synthesizes the key findings of the research, revisiting the synthesis of CeO_2 nanoparticles and the profound impact of laser fluence on their properties. It emphasizes the comparative advantages of the LAL method, highlighting its superior control over nanoparticle synthesis and its environmentally friendly nature. The chapter underscores the practical applications of CeO_2 nanoparticles in UV protection and biosensors, showcasing their improved performance and potential for future technological advancements. It also outlines prospects for further research, suggesting innovative approaches to enhance synthesis methods and explore new applications, thus paving the way for significant advancements in the field.

In summary, this paper uses a laser process to create CeO_2 nanoparticles, examines their optical and electrochemical properties in detail, and clarifies their generation and luminescence mechanisms, while also examining their applications in cosmetics and biosensors, making a significant contribution to philosophy. Therefore, this paper is deemed to be of sufficient value as a doctoral dissertation for a Doctor of Philosophy.