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Green Synthesis of Cerium Oxide Nanoparticles

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Abstract: Nano technology is one of the latest and fastest growing research methods. The present study describes the synthesis of the Cerium oxide nanoparticles by biological (green) method. Compared to the other methods green synthesis is the preferred method. This is because of less hazardous to the nature, cost effective, easily and abundantly available feature. Cerium oxide nano particles are synthesized from the Hibiscus Sabdariffa flower extracts by the method of Co-precipitation. The plant extract acts as the capping agent and as a reducing agent in the synthesis of nano particles. The synthesized Cerium Oxide nano particles were analyzed by Fourier Transform Infrared Spectroscopy, Particle Size distribution Scanning Electron Microscope (SEM) with the EDAX.

Keywords: Green synthesis, Cerium oxide, Hibiscus Sabdariffa, Fourier Transform Infrared Spectroscopy, Scanning Electron Spectroscopy.

I. INTRODUCTION

Nano biotechnology is currently applied in the different fields of science and engineering, like material science, Nano technology, biotechnology, chemistry, and environmental engineering. The synthesis method involved in the other chemical methods uses the large amount of energy and cause toxic to the environment. So there is a need to go for the alternate technique. The alternate technique should be environmentally friendly, economical and less hazardous to the environment.

Cerium oxide can be used in both acidic and alkaline medium. Cerium oxide nano particles used in the photocatalytic degradation process. The nano particles interacts with the $-OH$ and the O_2 and form the hydroxyl radicals. Due to the smaller size and larger surface area it can be used in the many applications in the environment to treat the contaminants in the waste water.

II. MATERIALS AND METHODS

All the materials used in the green synthesis of Cerium oxide nanoparticles are of analytical grade.

- 1) Distilled water
- 2) Cerium nitrate hexahydrate
- 3) Hibiscus Sabdariffa flowers extract

A. Preparation Of Extracts Derived From Hibiscus Sabdariffa Flower Extract

The Hibiscus Sabdariffa flowers were washed thoroughly in running tap water to remove soil particles and adhered debris and finally washed with sterile distilled water. Washed Hibiscus Sabdariffa flowers were air dried under shade at room temperature. In a typical procedure, 5 g of clean Hibiscus Sabdariffa flowers were weighed in a beaker and added to 200ml of distilled water. The solution was kept at room temperature for ~6 h. The obtained red solution was filtered twice using Whatman filters to eliminate any residual solids.

B. Synthesis Of Cerium Oxide Dioxide Nanoparticles

2.0 g of cerium nitrate hexahydrate $Ce(NO_3)_3 \cdot 6H_2O$ was added in 100 ml of the red Hibiscus Sabdariffa flower water extract solution. The solution was mixed homogeneously and gently heated for 3 h. A solid precipitate was observed upon cooling to room temperature. The solid deposit was purified by repeated centrifugation at 7500 RPM for 15 min. It was then dried in oven set at $100^\circ C$ and thereafter calcinated at $450^\circ C$ for 2 h using a high temperature muffle furnace.

C. Characterization Of Cerium Oxide Nanoparticles

The synthesized Cerium Oxide nanoparticles were characterized using the Field Emission Scanning Electron Microscope (SEM) with EDAX to find the morphology and the elemental composition. The small amount of synthesized nanoparticles was dried and placed on the double side carbon tape and to make the sample conductive gold coating was applied. The particle Size analysis and Zeta potential were measured using the Dynamic Light Scattering principle. Fourier Transform Infrared Spectroscopy analysis was carried out to find the functional groups of sample.

III.RESULTS AND DISCUSSION

A. Particle Size Analysis

The particle size distribution of the Cerium Oxide Nanoparticles was found out using the Particle Size Analyser. The Fig 1.1 shows the histogram of the Cerium oxide Nanoparticles, the particle size is around 200nm, due to the algometric effect during the calcination process. Fig. 1.2 shows the Zeta potential values of the particles. The zeta potential value is -35.6 mV. It shows the particle is highly stable in nature.

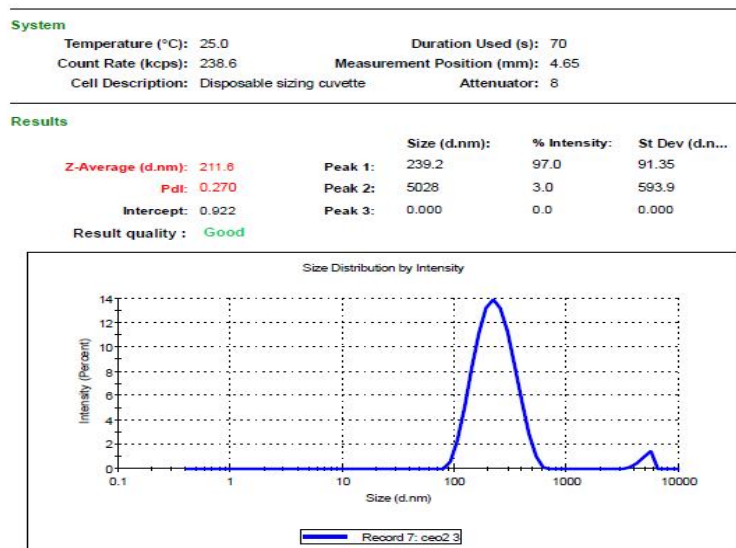


Fig. 1.1 Particle Size Distribution

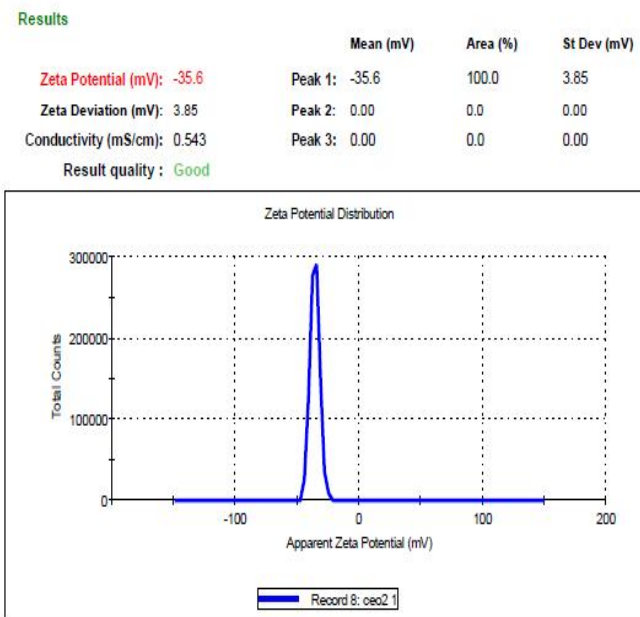


Fig. 1.2 Zeta Potential

B. Fourier Transform Infrared Spectroscopy (FTIR) Analysis

FTIR analysis was carried out using the Perkin Elmer FTIR analyzer. The peaks at 3514 cm^{-1} corresponds to -OH stretching of H_2O . Peaks in the range of 1300 cm^{-1} - 1800 cm^{-1} indicate the carbonate ion stretching vibration. i.e. Physical adsorption of water molecules. The Ce-O stretching band around 389.36 cm^{-1} confirms the fingerprint region of formation of cerium oxide nanoparticles. Fig. 1.3 shows the FTIR results of the Cerium oxide nanoparticles.

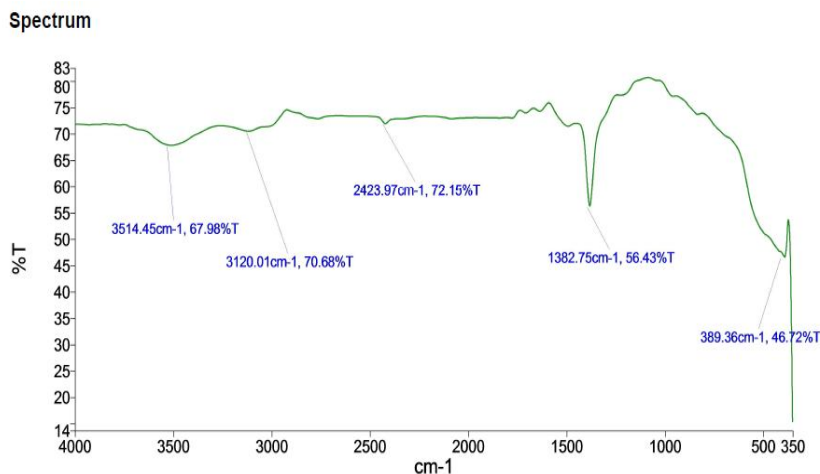


Fig. 1.3 FTIR spectrum results

C. Scanning Electron Microscopy (SEM) with EDAX

The Surface morphology of the prepared Cerium oxide particles was monitored using the FESEM. The SEM results clearly indicate the surface structure and morphology of the Cerium oxide nanoparticles. Fig. 1.4 shows the SEM results of the prepared Cerium Oxide nanoparticles. It shows most of the particles are well distributed. The quantitative compositional analysis of CeO₂ was carried out using EDAX. Fig. 1.5 shows the EDAX results of the Particles. From the results the elemental composition of the cerium oxide nanoparticles are 3.67%, 16.51% and 79.82% of the weight, respectively for the Carbon (C), Oxygen (O) and Cerium (Ce).

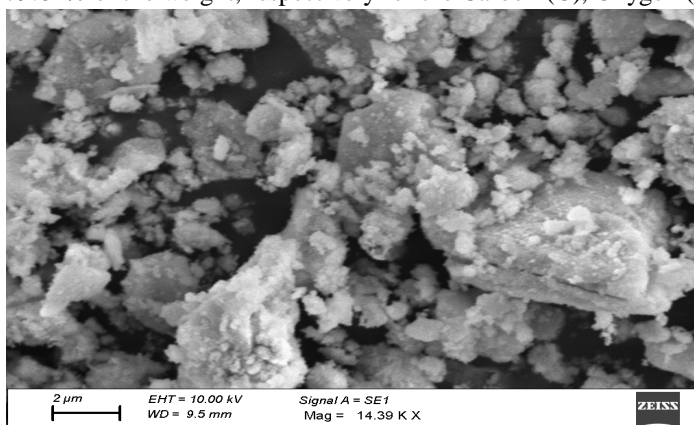


Fig. 1.4 SEM result

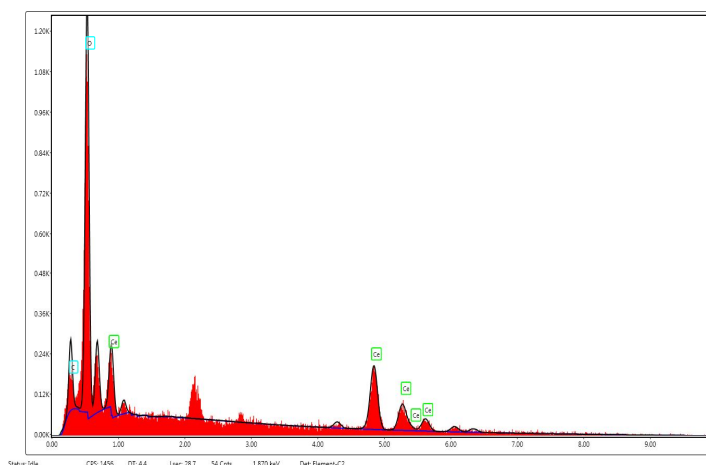


Fig. 1.5 EDAX result

IV. RESULTS AND DISCUSSION

The nanoparticles were synthesized by simple co precipitation method also as green method using Hibiscus Sabdariffa flowers extract. The flower extracts acts as a reducing agent and also act as capping agent. The following conclusions were drawn from the obtained results. The green method of synthesis of Cerium Oxide nanoparticles was rapid process, economical, less toxic to the environment and sustainable.

The characterization results like Fourier Transform Infrared spectroscopy and SEM clearly indicates the effective formation of the Cerium oxide nanoparticles. The peaks at 389.36 cm^{-1} from FTIR analysis clearly indicates the Finger Print region of the cerium.

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