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Bio Synthesis of Cerium Oxide Nanoparticles using Aloe Barbadensis Miller Gel

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Abstract- The synthesis of metal oxide nanoparticles with certain morphologies and sizes has become the matter of great interest in present experimental protocols. Bio synthesis production of metal oxide nanoparticles using plants is more desirable than physical and chemical methods due to its eco-friendliness. The objectives of this study were to report the potential of green chemistry to synthesize metal oxide nanoparticles. Furthermore, characterizations such as X-ray diffractometry, Fourier Transform Infrared Spectroscopy, Transmission electron microscopy and Particle Size Analysis of the nanoparticles were discussed.

Index Terms- biosynthesis; cerium oxide nanoparticles; aloe barbadensis miller

I. Introduction

In recent years, there has been increasing attention towards eco-friendly synthesis of metal oxide nanoparticles using plants, this is because though nanoparticles exhibit exceptional electronic, thermal, anti-bacterial properties compared to bulk particles, the nanoparticles synthesis causes lot of toxic byproducts. The green synthesized nanoparticles do not produce any toxic byproducts and also have reported to be more stable compared to chemically synthesized ones. Moreover, the rate of synthesis is also much faster.

Cerium(IV)oxide(CeO_2) Nanoparticles have numerous applications, mainly in the biomedical industry due to their strong antioxidant properties. These are amongst the highly used rare earth compounds possessing applications in industrial and commercial products. It is also an excellent absorber of ultraviolet radiation and can be used as an alternative for zinc oxide or titanium oxide nanoparticles in cosmetics.

Aloe barbadensis miller is also known as aloevera, which is a very short stemmed succulent plant. It produces two substance “gel” and “latex” which are used for medicinal applications. The chemical constituents of Aloevera are amino acids, anthraquinones, enzymes, minerals, vitamins, lignins, monosaccharide, polysaccharides, salicylic acids, saponins and sterols. Poly saccharides are very good thickening agents which encapsulates the cerium ions.

II. MATERIALS AND METHOD

2.1 Materials

Cerium(III) nitrate hexahydrate($Ce(NO_3)_3 \cdot 6H_2O$) was purchased from SD-Fine. Double distilled water was used throughout the process.

2.2 Preparation of alovera extract

Few big leaves from Aloe barbadensis miller plant were collected and washed thoroughly with water to remove any dirt or debris on the surface. Rind from the leaves was carefully peeled off using a sharp knife and discarded. The leaf was slit longitudinally into half, sharp edged spoon was used to scrap off the gel from the leaf into a sterile beaker.

2.3 Synthesis method

0.1M of *Ce*rium (III) nitrate hexahydrate was taken into a beaker and 40ml of distilled water was added to it. This solution was stirred using a magnetic stirrer until a homogeneous solution was formed. To this aqueous solution aloevera leaf extract of 10ml was added. The reaction mixture was stirred for 30 mins continuously. The solution was then heated on a hot plate at 80^oC till the supernant got evaporated. The obtained product was pounded into fine powder and calcinated at 600^oC for 2 hrs.

III. Results and Discussion

The obtained cerium (IV) oxide nanoparticles were characterized using X-ray diffractometer, Fourier Transform Infrared Spectroscopy, Transmission electron microscope and Particle size analyzer.

3.1 X-ray diffractometer

The X-ray diffraction was done for cerium (IV) oxide nanoparticles using x-rays with wavelength of 1.54 A^o. The XRD analysis was done before and after calcination. No peaks were observed in the graph plotted for cerium (IV) oxide before calcination.

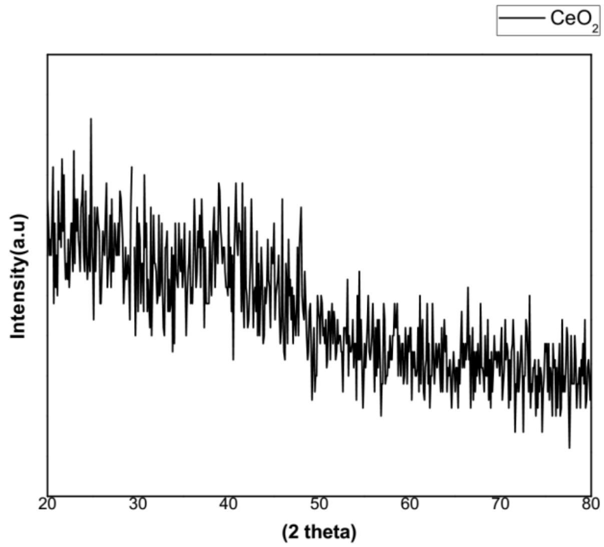


Figure 1. XRD graph of CeO_2 before calcinations.

The XRD was repeated after calcinating cerium(IV)oxide nanoparticles at 600°C for 2hours. The peaks were observed at 28.57, 33.13, 47.5, 56.38, 59.07, 69.5, 76.7 and 79.09 which correspond to planes 111, 200, 220, 311, 222, 400, 331 and 420 respectively. The obtained particles were confirmed to be cerium (IV) oxide using XRD graph. The structure was observed to be FCC cubic structure.

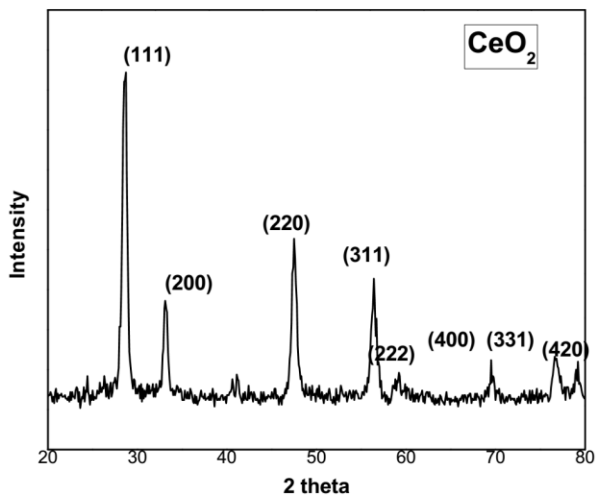


Figure 2. XRD graph of CeO_2 after calcinations.

3.2 Fourier Transform Infrared Spectroscopy

The FTIR spectroscopy was done within a range of 400-4000 cm^{-1}. The peaks were observed at 1417.73, 1653.03, 1384.94, 1151.54, 879.57 and 624.96 correspond to alkane, carbonyl, alkane, alkyl halide, alkene and alkylhalide with functional groups –C-H-, C=O, -C-H-, C-F, =C-H and C-Cl respectively. The observed functional groups in the obtained product are a result of the organic compounds like are amino acids, anthraquinones, enzymes, vitamins, lignins, monosaccharide, polysaccharides, salicylic acids, saponins and sterols present in the leaf extract of aloevera.

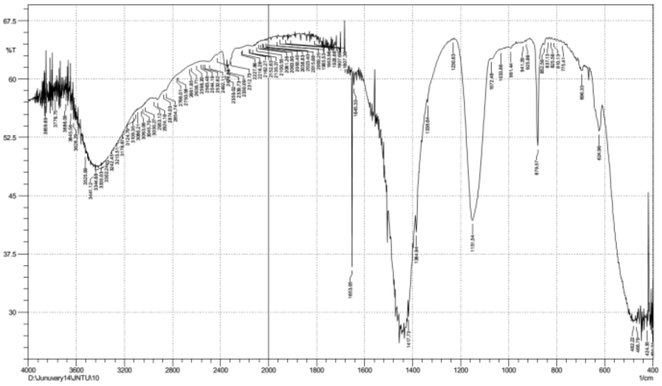


Figure 3. FTIR spectroscopy of CeO_2 nanoparticles.

3.3 Particle size analyzer

The particle size analysis was done using the dynamic light scattering technique. A small amount of cerium (IV) oxide nanoparticles were dispersed in distilled water and subjected to ultrasonication for 30mins. The dispersed solution was then analyzed under dynamic light scattering. The viscosity of the dispersion medium was found to be 0.8 mPa.s. The scattering angle was about 173°. The mean diameter of the particles summed up to 63.6 nm.

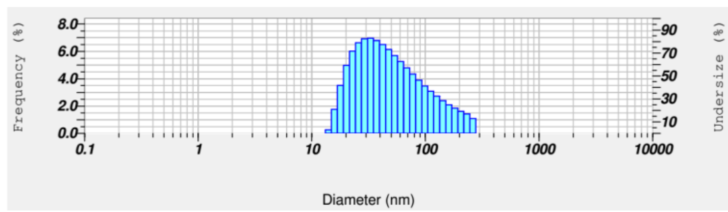
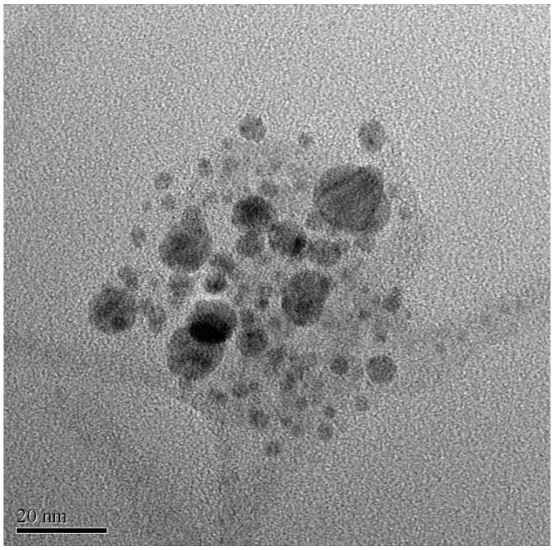
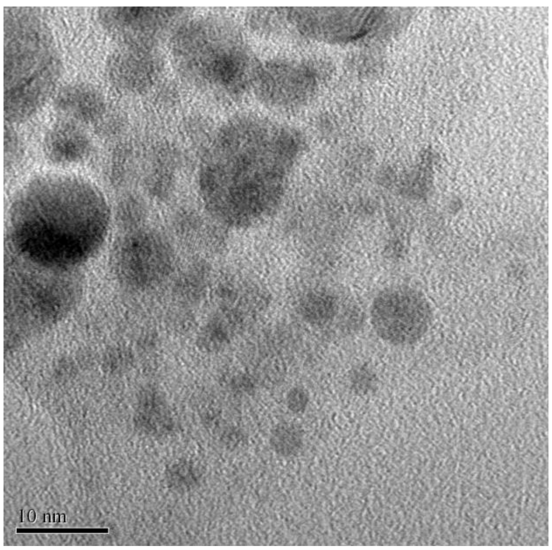


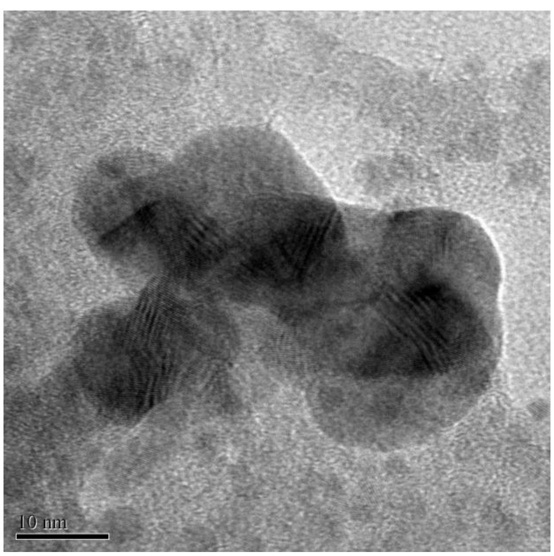
Figure 4. Dynamic light scattering plot for CeO_2 nanoparticles

3.4 Transmission electron microscopy

The morphology of the green synthesized CeO_2 nanoparticles was studied using TEM as shown in Figure 5, Figure 6 and Figure 7. Figure 8 is the SAED image of CeO_2 nanoparticles. It was observed that the growth of CeO_2 nanoparticles was spherical in shape.







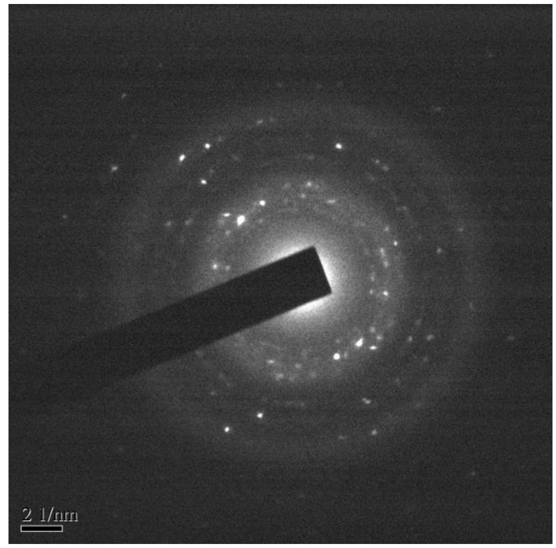


Figure5., **Figure 6.** and **Figure 7.** are TEM micrographs and **Figure 8.** is the SAED image of green synthesized CeO_2 nanoparticles.

IV. Conclusion

Successfully, cerium (IV) oxide nanoparticles were synthesized by a very simple and eco-friendly way using leaf extract of aloevera plant. The obtained product was confirmed to be cerium (IV) oxide, the crystal structure was studied and the d-spacing of CeO_2 nanoparticles was studied using XRD. The functional groups in the CeO_2 nanoparticles were studied using FTIR spectroscopy. The morphology of CeO_2 nanoparticles was studied using TEM micrographs. The average size of synthesized nanoparticles was calculated using dynamic light scattering technique.

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