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Full Length Research Article

Hibiscus rosa-sinensis Plant Extract – Assisted Synthesis, and Antibacterial Applications of CeO_2 Nanoparticles

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ABSTRACT

Hibiscus rosa-sinensis plant extract – assisted synthesis was performed to synthesize CeO_2 nanoparticles. All the produced materials were found to be dynamic under sunlight irradiation for the treatment against antibacterial activity. The synthesized CeO_2 nanoparticles were structurally characterized by FTIR and XRD techniques, which showed characteristics vibrations of successfully formed CeO_2 nanoparticles symmetry. SEM images revealed the CeO_2 nanoparticles like the spherical shaped materials. The optical response and detection of reactive species were carried out by photo-luminescence (PL) and showed emissions at 700 nm. PL data also used to calculate band gaps 3.72, eV of CeO_2 nanoparticles. UV/visible spectrophotometer scanned the photocatalytic competences of the synthesized nano materials. CeO_2 nanoparticles exhibited efficient antibacterial activity against human pathogens.

***Key words*:** Plant extract, CeO_2 nanoparticles, Anibacterial activity, FTIR, XRD technique

The quality of water reservoirs is diminishing as a result of rising residential and industrial human needs, which has harmed aquatic life [1-2]. A large number of research investigations are now being reported to prepare suitable photocatalysts for textile industry effluents treatment [3], which are considered more harmful than other toxins. About half of the dyes amount used on textile fibers do not adhere to it and end up as a contaminant in aquatic environment [4]. Using unhygienic water resulted in a variety of ailments in human beings [5-6]. Undiagnosed and untreated dye pollutants in water not only damage the surface of water, but they also block the transmission of light, which has negative consequences for water bodies [7]. Various techniques are in practice to remove these pollutants from water such as catalysis [8], photodegradation [9-10], biodegradation [11] and adsorption [12-15]. Efficient removal of azo dyes cannot be achieved by traditional adsorption, enzymatic degradation and ion exchange procedures because they produce secondary harmful emissions such as poisonous fumes and sludge, which necessitate further processing [16-22]. Alternative strategies, such as heterogeneous photocatalysis with micro semiconductors, have emerged as potential technologies for removing dye contaminants from waste water [23-30].

MATERIALS AND METHODS

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Initially, mixing cerium nitrate, *Hibiscus rosa-sinensis* plant extract in 20 ml of water. The colloidal solution was filtered, washed (with distilled water) and dried (at 95°C for 12 hrs) to obtain product. The solid product CeO_2 nanoparticles was obtained by filtering, washing (with distilled water) and drying (at 100°C for 12 hrs). Finally, annealing of dried CeO_2 nanoparticles at 550°C conceded in furnace over 5 hrs to deduce energetic CeO_2 nanoparticles. Fourier transformed infrared (FTIR) spectrometer was used for the identification of different functional moieties in the synthesized materials. X-ray diffractometer (XRD) revealed structural characteristics of CeO_2 nanoparticles. Ultra-violet visible (Uv-vis.) spectrophotometer and Photo-luminescence (PL) studies were used to enlighten the optical nature, while EDX scanning electron microscope (EDX-SEM) examined the elemental elucidation with surface texture of CeO_2 nanoparticles.

RESULTS AND DISCUSSION

XRD analysis

XRD studies are employed for the structure demonstration of CeO_2 nanoparticles. Highly strong diffraction peaks were recorded which have 100, 200 and 220 hexagonal reflection planes [30-34]. The observed diffraction data showed that CeO_2 nanoparticles provided hexagonal foundation, which was manifested by results of CeO_2 nanoparticles in (Fig 1). Scherer's equation used to determine the crystallite size of the most intense diffractions of CeO_2 nanoparticles which was found to be 8.34 nm. These productive results showed further reduction in particle size of CeO_2 nanoparticles (average crystallite size = 12.30 nm).

FT-IR analysis

FTIR examined the characteristic peaks at 472, 519, 793, 1011, 1370 and 3415 cm^{-1} are attributed to the CeO_2 nanoparticles as shown in Fig. 2. The variation in FTIR peaks of CeO_2 nanoparticles revealed the successful formation of CeO_2 nanoparticles. The vibrations recorded ranging 472-532 cm^{-1} demonstrating the presence of cerium connections with oxygen in the material structures. However, vibration peaks at 1363-1370 cm^{-1} and 3415-3444 cm^{-1} were due to C-H bending and stretching respectively. All these spectral results were in favor of metal-oxygen interactions in organo silica framework [35-39].

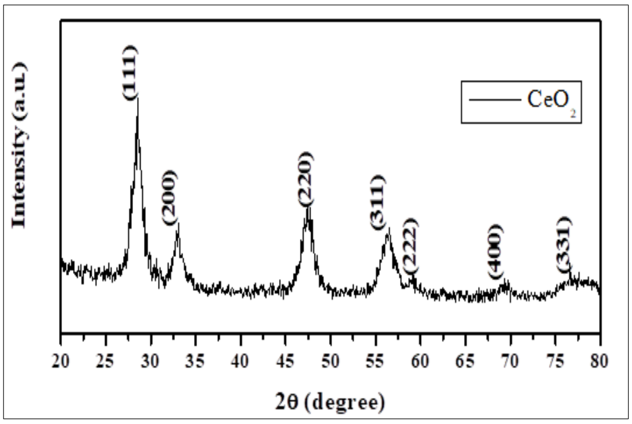

Fig 1 Powder XRD patterns of CeO_2 NPs

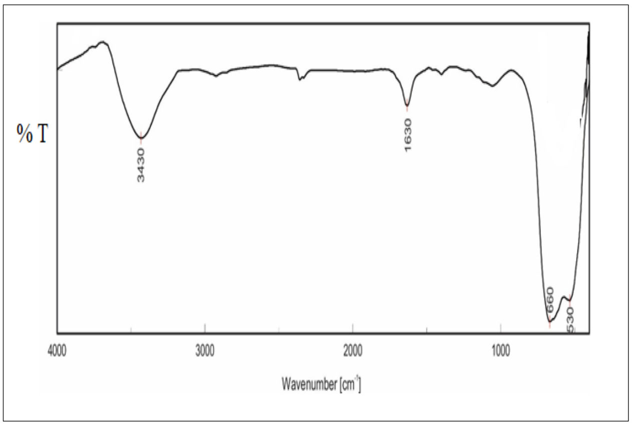

Fig 2 FT-IR spectra of CeO_2 NPs

SEM analysis

SEM images exhibited particles like organizations in CeO_2 nanoparticles as shown in (Fig 3). To further ascertain the formation of CeO_2 nanoparticles, SEM analysis was carried out to examine the surface morphology. The tiny spheres of cerium oxide nanoparticles was formed and agglomerated.

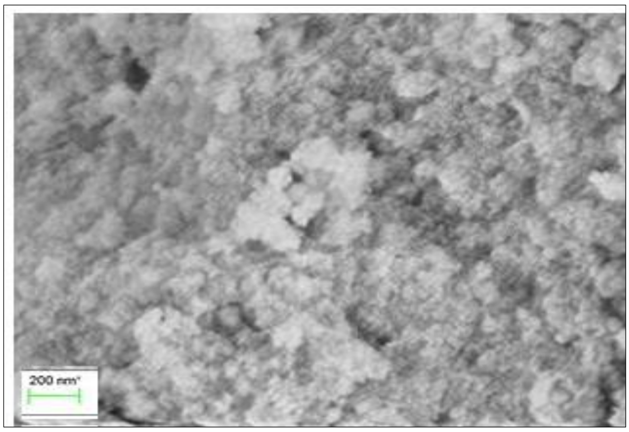

Fig 3 SEM images of CeO_2 nanoparticles

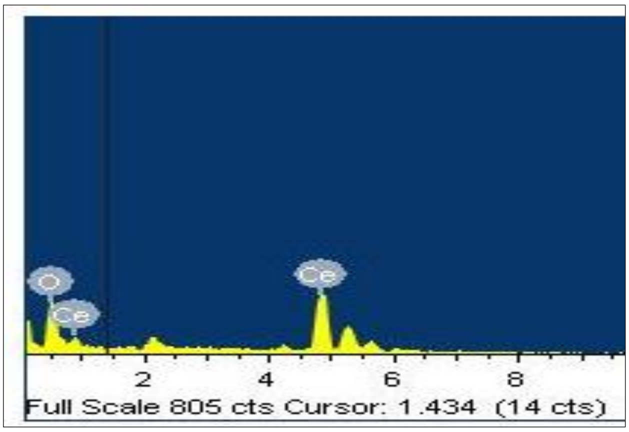

Fig 4 EDX spectra of CeO_2 nanoparticles

EDX analysis

EDX results in (Fig 4) confirmed the CeO_2 nanoparticles formation. The EDX spectra procured during the SEM analysis was used to confirm the elemental composition of the as prepared sample. (Fig 4) depicts the EDX spectra of the CeO_2 nanoparticles.

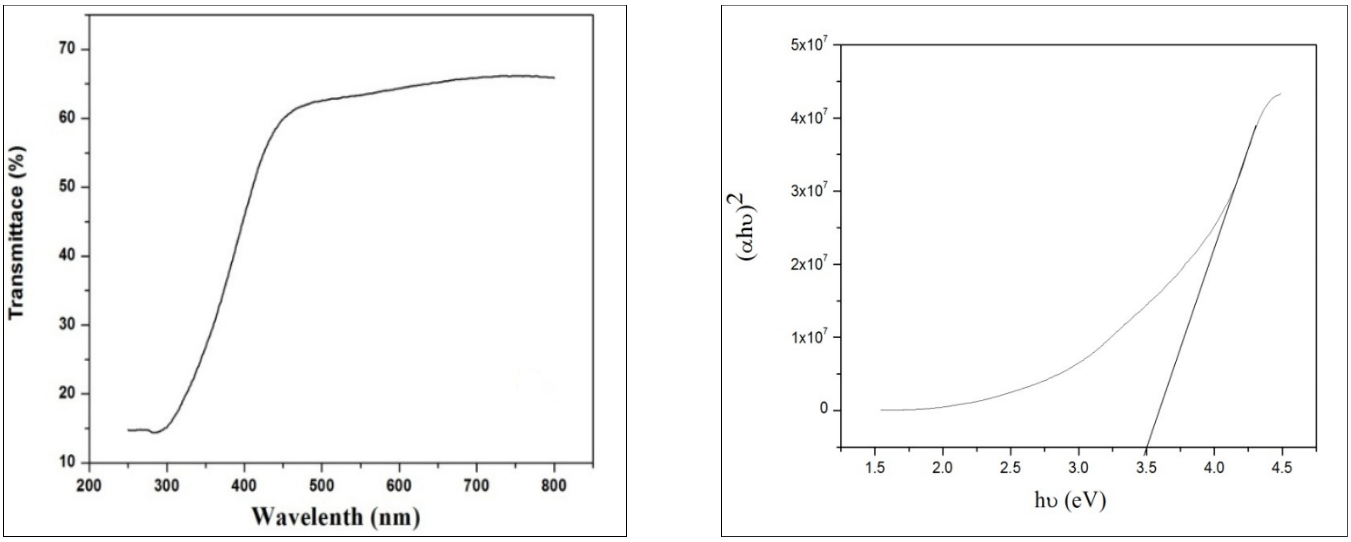

Fig 5 UV-Vis spectra of CeO_2 NPs

UV-Vis spectroscopy studies

Tauc plots in (Fig 5) showed energy difference between valence band (VB) and conduction band (CB) in CeO_2 nanoparticles. These band gaps were determined 3.45 eV for CeO_2 nanoparticles.

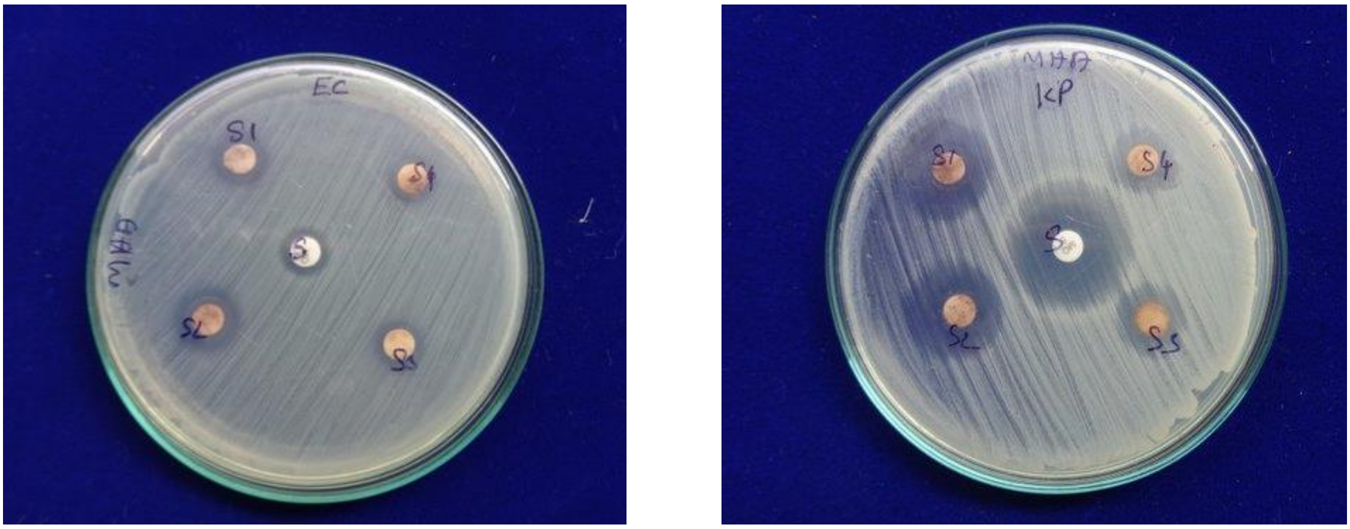

Fig 6 Antibacterial activity of CeO_2 nanoparticles

Antibacterial activity

Data presented in (Fig 6) shows the antibacterial activity of CeO_2 nanoparticles s were investigated against gram negative (Klebsiellapneumoniae) and gram positive (Staphylococcus aureus) bacterial strains, respectively. From the images, it was found that there is no zone of inhibition over the control, which clearly shows that the zone of inhibition increases and influences higher antibacterial activity [40-46]. The particle size and surface area of the samples play a vital role in the antibacterial activity of synthesized samples.

CONCLUSION

The present research work comprised revised study of CeO_2 nanoparticles and SEM images provided foundation for the large surface area in CeO_2 nanoparticles. CeO_2 nanoparticles was validated by significant outcomes of XRD, PL, FTIR and EDX-SEM. Furthermore, the Antibacterial activity efficiencies of CeO_2 nanoparticles exhibited their improved. The distinctive approach to formulate energetic CeO_2 nanoparticles having exciting Antibacterial activity accomplished the current study more effective.

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