Research Article

Journal of Environmental Nanotechnology

Synthesis and Characterization of Pure Zirconium Oxide (ZrO_2) Nanoparticles by Conventional Precipitation Method

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Received: 24.11.2021 Accepted: 04.12.2021 Published: 30-12-2021

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ABSTRACT

In this paper, the synthesis of Zirconium oxide (ZrO_2) nanoparticles was carried out by the conventional precipitation method. Ultraviolet, visible spectroscopy (UV-Vis) and dynamic light scattering analysis (DLS) were performed to find the particles' bandgap and size. Fourier transform infrared spectroscopy (FT-IR) observed the characteristic bands of Zirconium oxide nanoparticles. Dynamic light scattering analysis showed that the size of the particle was found to be 119 nm.

Keywords: ZrO_2; UV-Vis; FT-IR; Hydrothermal.

1. INTRODUCTION

In recent years nanoparticles have exhibited unique applications due to photocatalytic, optical and antibacterial properties. Among widegap ceramic materials, zirconium oxide is one of the important ceramic materials used in engineering applications. The technique is widely used for gas sensor fabrication, development of metal oxide semiconductors and ceramic devices and used as catalyst support material (Ayanwale *et al.* 2018). ZrO_2 is used in various biomedical, electronics and communication domains because it possesses high strength, high mechanical toughness and high thermal stability. ZrO_2 nanoparticle exists in different bases on their temperature and it exists in tetragonal and cubic structures at above room temperature (Bumajdad *et al.* 2018; Precious Ayanwale *et al.* 2019). The conventional precipitation method is one of the approaches to prepare a variety of nanoparticles by using water as a solvent of the reaction. The nanoparticle formation depends on chemical parameters like composition and concentration of reactants and thermodynamic parameters, including temperature, pressure and reaction time (Rushton *et al.* 2019).

2. EXPERIMENTAL DETAILS

2.1 Materials and Methods

Zirconium (IV) oxychloride octahydrate ($ZrOCl_2.8H_2O$, AR grade), Potassium hydroxide (KOH, AR grade) and Millipore water were used to prepare aqueous solution.

To prepare pure zirconium oxide nanoparticle, 100 ml of distilled water was added to dissolve 0.3 M of $ZrOCl_2.8H_2O$ by effective stirring at room temperature. Then the stirred solution was mixed with 0.6 M of potassium hydroxide solution. After 1 hour, the white solution formed was poured into an autoclave and placed in a microwave oven at 180°C for 16 hours. The resultant residue was purified many times with millipore water followed by ethanol to remove the impurities. The final product was calcined at 500 °C for 5 hours.

3. MATERIAL CHARACTERISATION

UV-Vis spectroscopy of the samples was taken by UV Visible spectrometer (DRS) – Analytekjena, Germany. Size distribution of nanoparticles was determined by Zeta sizer (Horiba, Japan). ATR-FTIR, Germany, observed the characteristic bands of Zirconium oxide nanoparticles.

4. RESULTS AND DISCUSSION

4.1 UV-Visible Spectra

Fig. 1 shows the optical absorbance of the ZrO_2 nanoparticles. It exhibited an absorbance peak at 210 nm, representing the oxide species' charge transfer to the zirconium cation. A semiconductor with a wider bandgap may be used in compact disc read-write heads and light-emitting diodes. Compared with the previous reports, the absorbance of ZrO_2 is slightly blue-shifted due to the size of the particle and lattice parameters leading to a large amount of bandgap. The bandgap was found to be 5.90 eV.

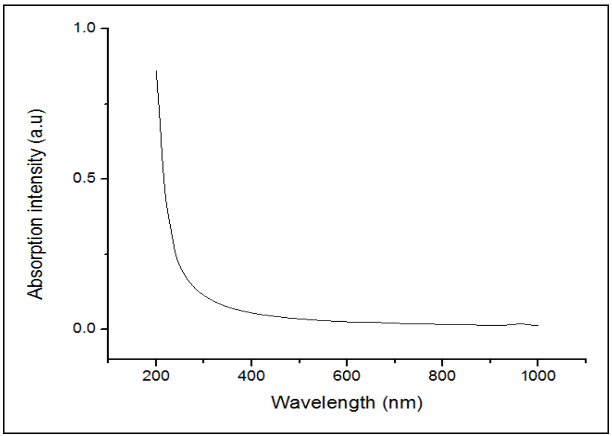

Fig. 1: UV-Visible Spectra of Pure ZrO_2

4.2 FTIR

Fig. 2 shows the Fourier transform infrared spectrum of prepared ZrO_2 nanoparticles. The peak at 1644 cm^{-1} denotes the O-H stretching and bending vibration of absorbed water. The peak around 1560 cm^{-1} corresponds to the adsorbed moisture (Singh *et al.* 2014). Further, the band situated at 1456 cm^{-1} represents the hydrated molecules in the hydroxyl group (Sagadevan *et al.* 2016). While the peak at 600 cm^{-1} corresponds to Zr-O vibration (Zinatloo-Ajabshir *et al.* 2016).

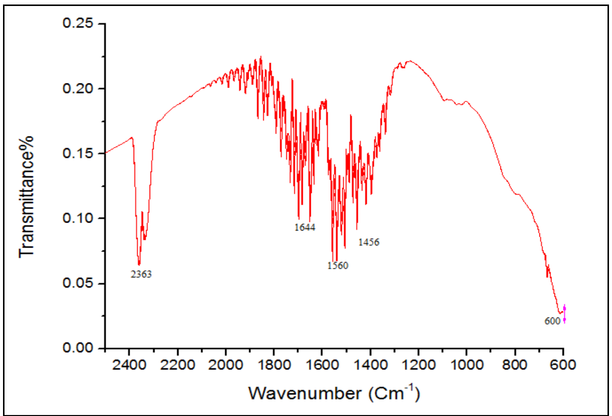

Fig. 2: FTIR Spectrum of Pure ZrO_2

4.3 Dynamic Light Scattering Analysis

The size distribution of ZrO_2 nanoparticles in de-ionized water was found out by dynamic light scattering analysis. From Fig. 3, the size of the particle was found to be 119 nm. From the DLS analysis result, ii was obvious that the particle size greater than 100 nm leads to higher agglomeration.

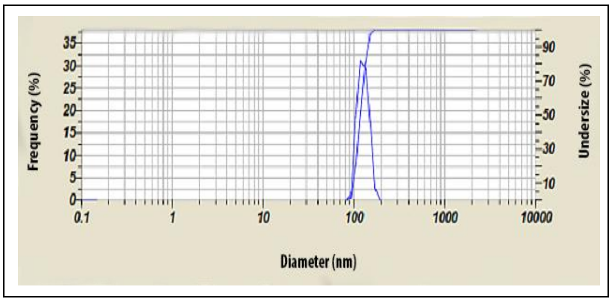

Fig. 3: DLS analysis of pure ZrO_2

5. CONCLUSION

ZrO_2 nanoparticles were prepared using the conventional precipitation method. The functional groups were ensured from FT-IR spectroscopic studies. The UV-Vis spectroscopic results show that it possesses a wide bandgap. Due to this wide-bandgap, it is used in many engineering applications such as gas sensor fabrications and metal oxide semiconductors.

FUNDING

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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