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Synthesis Of TiO_2 Nano Material And Their Applications In Device Applications

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A B S T R A C T

Nanomaterials play a relevant role in different biomedical studies. NPs of metal oxide have attracted attention due to their unique properties. This study presents information on tetragonal anatase phase Titania nanoparticles. A simple sol gel process has been used for synthesis of TiO2 nano material and was characterised by X-Ray Diffraction for structural and UV-visible for optical properties. The Ohmic behaviour was revealed from I-V measurements. The results suggest that the synthesised material is very suitable for device applications.

Keywords: Nano, Sol gel, XRD, Optical and I-V

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Introduction

TiO_2 has intriguing properties; the scientific community prefers the titanium dioxide (TiO_2) material for a variety of applications. As the photo anode material, TiO_2 is the foundation of economically viable for solar cells. As a result, it has been extensively researched how to modify the band structure of TiO_2 to improve its optical properties for optoelectronic devices applications [1−4]. Various experimental findings have demonstrated that the optical, morphological, compositional, electrical, and acoustical properties of metal oxide thin films serve excellent applications in these fields. With deposition techniques like DC magnetron sputtering [5], chemical bath deposition [6], spray pyrolysis [7], sol gel spin coating [8], pulsed laser deposition [9], electro deposition [10], thermal evaporation deposition [11], molecular beam epitaxy [12], and chemical vapour deposition [13], these films have been created on a variety of substrates. Among such metal oxides, TiO_2 has been widely used in nanotechnology industries because of its high stability, accessibility and unique photoelectric properties [5, 6].

Sol-gel synthesis has been an excellent technique for the assemblage of metal oxides like TiO_2 that exhibit prolific ordering on nano and micro scales. With this technique, there is proper administration of the whole reactions involved during the synthesis of the compounds. In this paper, we have reported the low cost synthesis of TiO_2 nanoparticles by wet chemical sol-gel route with enhanced optical absorption properties.

2. Experimental

We used anhydrous ethanol (C_2H_5OH, Carlo Erba) to dissolve 0.5 M of titanium (IV) butoxide ($Ti(OBu)_4$, Sigma Aldrich) followed by the addition of 100 ml of distilled water and 5 ml of GAA. Thus prepared solution was continuously stirred and after 10 minutes, the mixture showed signs of gel formation. The mixture was then stirred in a magnetic stirrer for 2.5 hours prior to heating. Next the mixture was dried in a oven at 60 °C for 24 hours and at 80^0C for 22 hours. The dried mixture was further annealed for two hours in an electric furnace at 600 °C and white TiO2 powder was obtained. The schematics are shown in fig.1.For the preparation of TiO_2 solution, the materials that were used are: (i) Titanium Butoxide (TTIB) that acts as a precursor (ii) Glacial acetic acid (GAA) which is a stabilizing agent (iii) Deionised water for hydrolysis process and (iv) Anhydrous ethanol

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as a solvent[14].

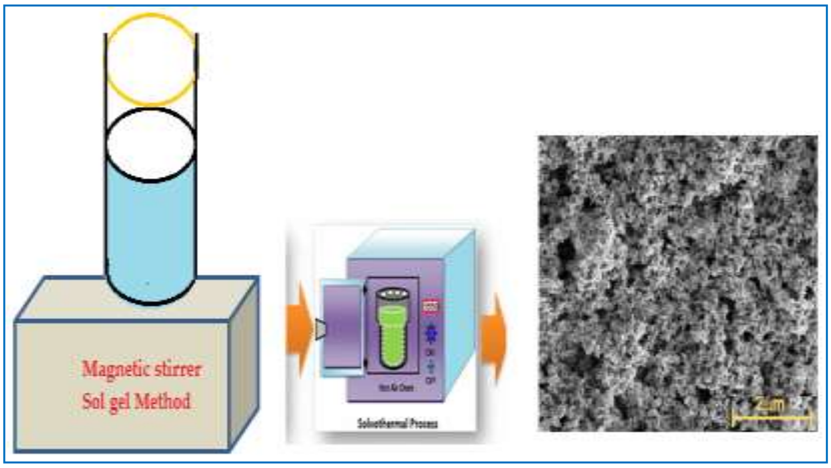

Fig.1: Sol gel process for synthesis of nano TiO_2 powder

3 Results and Discussion

3.1 Structural Analysis

The synthesised Titania nanoparticles' X-ray diffraction pattern is depicted in Fig. 2 and the peak information is clearly shows. The presence of erroneous diffractions is a sign of crystallographic. The experimental XRD pattern and the JCPDS card number are in agreement. 21-1272 (anatase TiO2) and other literature describing the XRD pattern of nanoscale TiO2 particles [8]. The TiO2 anatase structure is confirmed by the 2 at peak 25.4° [15]. TiO_2 in the anatase phase is indicated by strong diffraction peaks at 25° and 48° [16]. The sample contains no erroneous diffraction peaks. Its anatase structure is supported by the 2 peaks at 25.27° and 48.01°. Broad diffraction peaks show that the formed nanoparticles are crystalline based on the sample's intensity of XRD peaks.The particle size f the power is calculated by using Debye–Scherrer's formula and it come out to be 42.33nm.

$$D = \frac{0.94\lambda}{\beta Cos\theta} \qquad (1)$$

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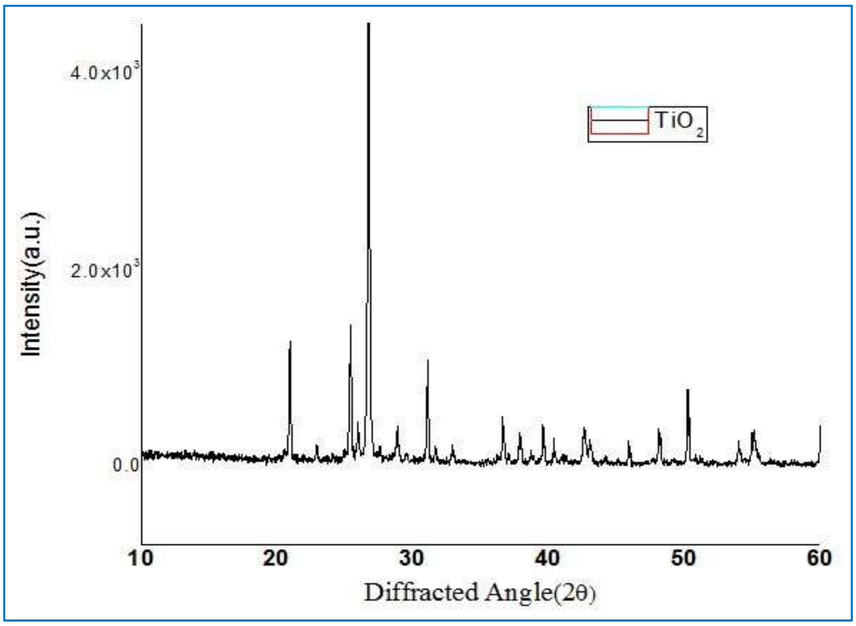

Fig.2: XRD pattern of TiO_2 nano powder

3.3 Scanning electron microscopy (SEM)

The SEM images of the prepared TiO_2 NPs are displayed in Figure 3. Scanning electron microscopy was used to examine the surface morphology of the TiO_2 NPs. The SEM images demonstrate that the NP conglomerate increased the size of the TiO_2 NPs12 and that their morphology was uniformly spherical but porous in nature.

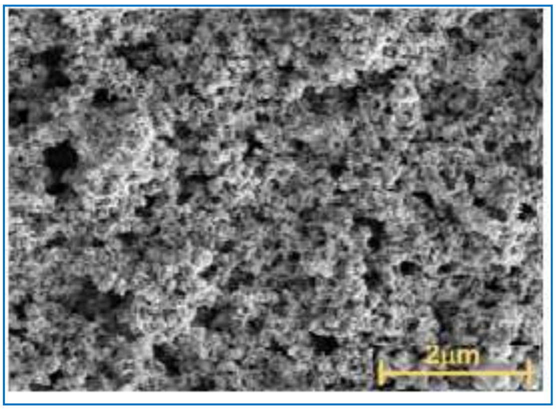

Fig.3:SEM image of TiO2 powder.

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3.4 UV-Visible

Figure 4 shows the UV-Vis absorption spectra of TiO_2 and was carried was carried out by using a out by JASCO-750 UV-Vis spectrophotometer. The figure shows the λ_{max} of the synthesised sample at 332nm .the optical band gap of material can be calculated according to Alberts Einstein relation[17]:

$$E = h\frac{c}{\lambda} = \frac{1240}{\lambda_{\max}} \quad (2)$$

From the above relation the energy band gap value of the prepared material is 3.73eV

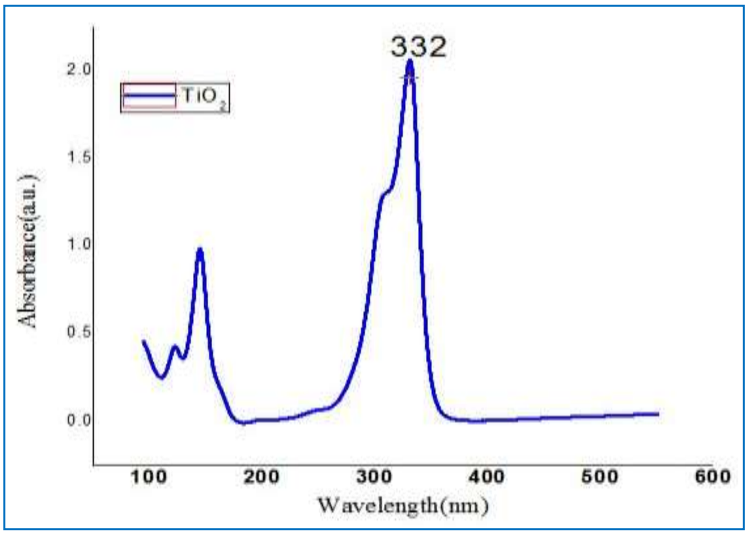

Fig.4: absorbance spectra of TiO2 powder

3.5 Electrical conductivity: I-V Characteristics

The electrical conductivity were observed by using resistance measurement by using digital multimeter equipment and by applying the resistance measurement, the conductivity of TiO_2 powder. The equation below is a formula to calculate [18]

$$\rho = \frac{\pi t(V|I)}{ln2} \quad (3)$$

where ρ is the resistivity (Ω cm), t is the sample thickness (cm), V is the measured voltage and I is the source current (A).

Here $\sigma = 1/\rho$ which gives conductivity of the sample 6.3×10^{-7} ($\Omega^{-1}m^{-1}$).

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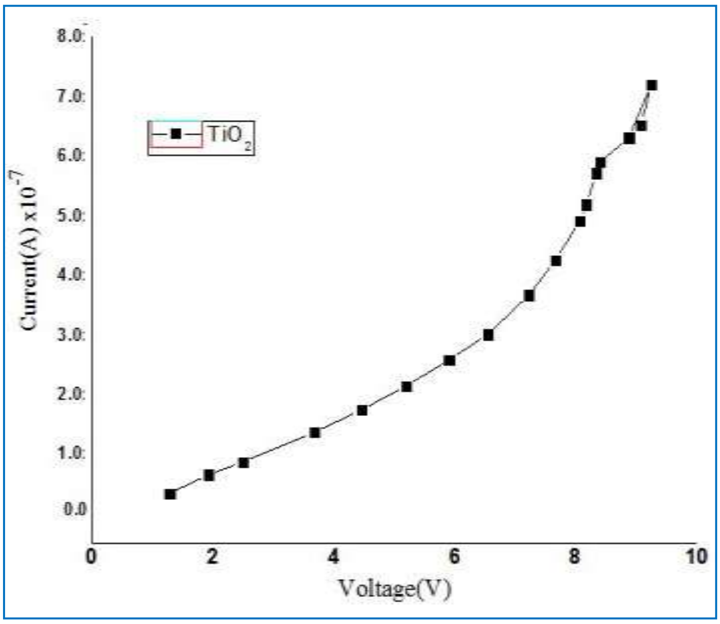

Fig.5: I-V characteristics of TiO2 powder

Conclusion

The TiO_2 powder sample prepared by sol gel technique. XRD analysis, regular phases of tetragonal anatase and Titania. UV-visible shows direct band gap of 3. 73eV.The electrical nature was confirmed by using I–V characteristics, and the results show linear behavior. From the value of results, it can be concluded that sample is suitable for device applications.

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