| Research Article | AKNU Journal of Science and Technology | AKNU JST |
|---|---|---|
| Volume 1 | Nannaya Vignana Bharathi | Issue 1 |

# Optical and Magnetic Properties of Titanium dioxide Nanoparticles

**S Rajyalakshmi[1*], RS Dubey[2], V TejeswaraRao[3], Ajit Kumar[4]**

*[1]Department of Physics, AdikaviNannaya University, Rajamahendravaram, AP, India,*
*[2]Swarnandhra College of Science & Technology, Narsapur, AP, India*
*[3]Department of Chemistry, MVR College, Visakhapatnam, Andhra Pradesh 530045, India*
*[4]1Department of Physics, GGMSc. College Jammu, Jammu, India.*

## Abstract

In the Research world nano particles plays a prominent role and have huge range of applications owing to their far-racing usage in different fields in the day to day life. The Semiconducting transition metal oxide Titanium dioxide (TiO2) aquirebetter ultraviolet obscure affect such as antibacterial and photocatalytic properties.It is an optimistic substance for the preparation of organic inorganic composite materials.It exists in crystalline as well as amorphous forms.In the present investigation Titanium dioxide (TiO2) powder was synthesized by Sol-gel techniqueby usingtitanium (4) isopropoxide (TTIP) as precursor. The XRD analysis affirms the phase and observed peaks are in good accord with the standard spectrum (JCPDS no.: 21-1272 and 21-1276). SEM affirms the particle size in the range of nano-meter.SEM image appears the arrangement of nano particle results in uneven arrangements with a size between 55.6 and 68.8 nm. Owing to its nano size the optical spectra confirm the enhancement of strong and prominent absorption and its spectrum band with maximum around 210 nm. FTIR recorded at room temperature in the region of 4000–400 $cm^{-1}$ which confirms the functional groups. ESR confirms the magnetic properties of the sample.The magnetic resonance field of the ESR signal can be influenced by exchange interaction, soappear in a Dyson line shape and g factor with g = 2.

**Keywords:** XRD, ESR, SEM, Isopropoxide.

| Article History | Correspondence | How to cite? |
|---|---|---|
| Received : 21-01-2022<br>Revised : 29-07-2022<br>Accepted: 18-08-2022 | Rajyalakshmi S<br>Email: srl.phy@aknu.edu.in | Rajyalakshmi S, Dubey RS, TejeswaraRao V, Kumar A. Optical and magnetic properties of Titanium dioxide Nanoparticles. AKNU Journal of Science and Technology 2022; 1(1): 66-72. |



## 1. Introduction

In the Research world nano particles plays a prominent role and have huge range of applications owing to their far-racing usage in different fields in the day to day life. Titanium dioxide(TiO2) can be largely used in industrial, food, environmental protection and in different fields. Due to the unique technological properties and applications such as dye-sensitized solar cell (DSSC) sensors, memory, solar cells devices photo catalysis and dye-sensitized solar cell (DSSC) [1-5]. Titanium dioxide exists in both crystalline and amorphous forms and mainly exists in three crystalline polymorphous, namely, anatase, rutile and brookite. Anatase and rutile have a tetragonal structure, whereas brookite has an orthorhombic structure Mahshid et al [6]. The immobilization of TiO2 nanoparticles on an appropriate support has been widely accepted since it could help to eliminate the costly phase separation processes and to promote the practicality of such catalysts as an industrial process.

Recently, photocatalytic activity of immobilized TiO2 particles on microporous ceramic alumina foams has been reported Plesch et al. [7]. It was found that reticulated macroporous ceramic foam with an open three-dimensional structure and low flow resistance improving the light penetration and fluid flow is highly promising support for photocatalytic applications and water purification systems. Several methods of TiO2 preparation have been reported in literature based on the hydrolysis of acidic solutions of Ti (IV) salts. Also, oxidations of TiCl4 on gaseous phase [8–10] and hydrolysis of titanium alkoxides [11, 12] have been used to generate finely divided with a high purity TiO2 powders.

## 2. Experimental

### 2.1. Synthesis of tio2nano materials

$TiO_2$nano particles was prepared using solgel technique. For the preparation of $TiO_2$ nano particles titanium (4) isopropoxide (TTIP) used as precursor, ethanol and de ionized water as catalysts. For preparation of $TiO_2$ nanoparticles under concentrated conditions (TTIP) (0.03 molar), deionized water (0.01 molar), Ethanol 20 ml and the solution was stirred at a temperature 60 °C with a constant stirring for about two hours for nucleation and growth of the nanoparticles.After reaction, the precipitate was collected by centrifugation, washed two times with acetone and three times with methanol followed by drying under ambient conditions. Then, the samples were sintered in a muffle furnace at a temperature of 120 °C for 1hour and then cooled for 2 hours. Finally, the samples are naturally cooled down to room temperature in which Titanium Oxide was formed.and fully ground for further investigations.

### 2.2. Characterization

Powder X-ray diffraction (XRD) studies were carried out using a Philips powder X-ray diffractometer (model PW 1071) with Ni filtered Cu-k radiation. The lattice parameters were calculated from the least square fitting of the diffraction peaks. UV-Vis absorption spectra were measured by Labindia analytical UV3092 spectrophotometer. Fourier transform infrared spectra (FTIR) of the sample was recorded between the wave number 500-4000 $cm^{-1}$ by using a Bruker Alpha-T FTIR spectrometer. Morphologies of the samples and the elemental composition investigation have been done by utilizing a field emission scanning electron microscope FE-SEM Supra 55 (Carl Zeiss, Germany) with an inbuilt energy dispersive X-ray analysis (EDAX) system.

## 3. Results and Discussion

### 3.1. XRD Studies

The structural analysis of TiO2 particles was carried out using XRD instrument. The diffractograms were recorded in the 2θrange of 20-70º. Figure 1 shows representative XRD patterns taken from Sol residues. The crystalline nature was observed in the powder XRD of TiO2 and diffraction peaks belong to phase of TiO2. All observed peaks are in good agreement with the standard spectrum (JCPDS no.: 21-1272 and 21-1276). The crystalline nature was observed in the powder XRD of TiO2 and diffraction peaks belong to rutile and anatase phase of TiO2.

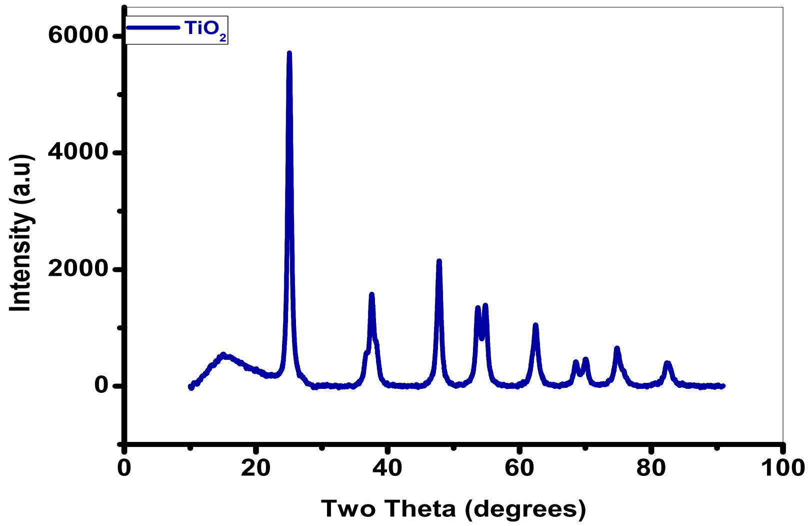


**Figure 1.** XRD patterns of $TiO_2$.

### 3.2. UV–Vis Spectroscopy

#### 3.2.1. Absorption Spectrum and Optical Band Gap Analysis

The UV-Vis absorbance of the sample was measured using a LABINDIA UV 3092 UV-Vis Spectrophotometer. The absorbance spectra of ZnO nanoparticles were recorded by distributing the particles uniformly in solvent Ethelyne glycol in the wavelength range of 190–800 nm to estimate the optical energy band gap. The Figure 2 shows strong and prominent absorption spectrum band with maximum around 210 nm. The energy band gap was determined by plotting Absorption coefficient and band gap from which the direct band gap was obtained 4.5 eV depicted in Figure 3.

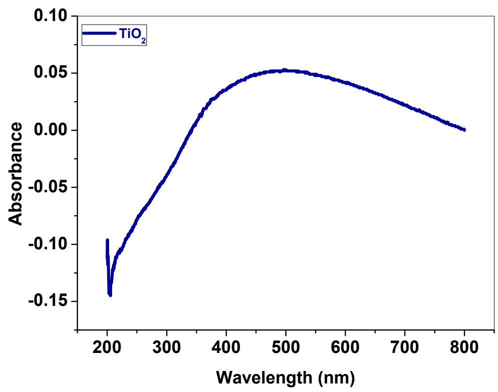


**Figure 2.** UV-Vis Absorbance spectrum of $TiO_2$.

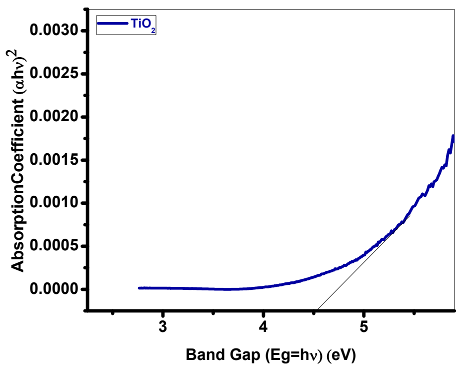


**Figure 3.** Optical Band gaps of pure $TiO_2$.

### 3.3. FTIR Spectroscopy

Fig 4. shows FTIR spectrum of titanium dioxide nanoparticles in which the peaks at 3400and 1631.78 cm-1, in the spectra are due to stretching and bending vibration of the –OH group. The as-synthesized $TiO_2$ dried samples were investigated by FTIR spectroscopy recorded at room temperature in the region of 4000–400 $cm^{-1}$. A small C H bond stretching is observed at 2338 $cm^{-1}$and 1334 $cm^{-1}$respectively which were assigned C H bending and stretching vibrations in the sample. The peaks at 468 $cm^{-1}$to 700 $cm^{-1}$ shows bending and stretching mode of Ti-O-Ti. There is no peak at 2900cm-1 which means all organic compounds removed from the samples after Calcinations [13].

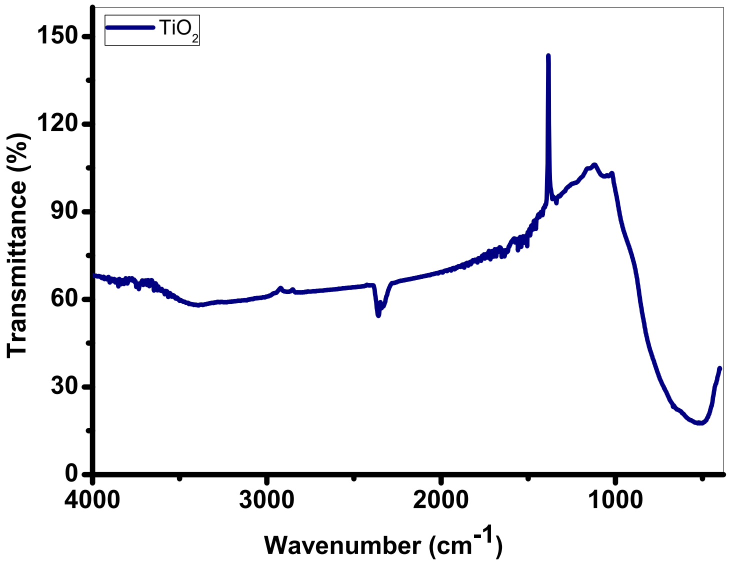


**Figure 4.** FTIR spectra of $TiO_2$ nano powder.

**3.4. SEM with Energy Dispersive X-ray Analysis**

Figure 5(a) shows the Scanning Electron Microscope (SEM) images of $TiO_2$ sample. Crystallization of particles were observed in the present sample. It is clearly seen from the SEM image of $TiO_2$ shows the formation of nano particle which result in irregular arrangements with a size between 55.6 and 68.8 nm, which may be due to agglomeration among the particles during sintering. SEM image has roughly spherical spongy shape. For further support concerning composition percentage was achieved by energy dispersive X-ray spectrometer (EDS) spectrum which was demonstrated in Figure 5(b). Quantitative results of $TiO_2$ nano particles were depicted in Figure 5(c).

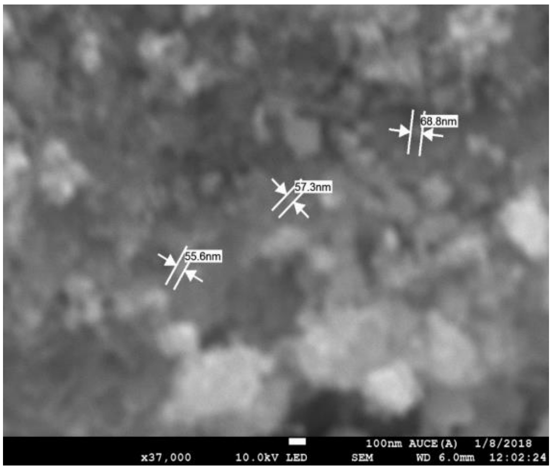


**Figure 5(a).** FE-SEM image of $TiO_2$ nano particles

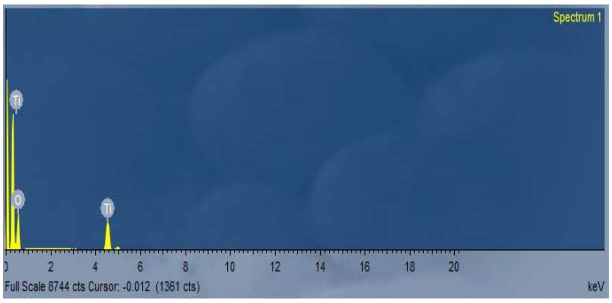


**Figure 5(b).** EDAX spectrum of $TiO_2$ nano particles.

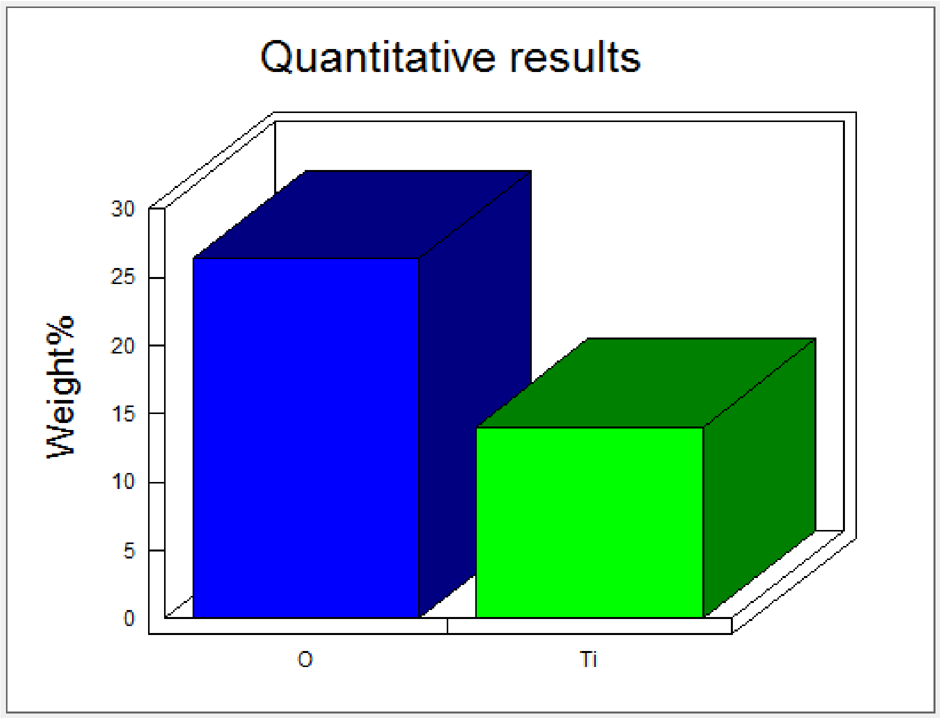


**Figure 5(c).** Quantitative results of $TiO_2$ nano particles.

### 3.5. Electron Spin Resonance Spectroscopy (ESR)

ESR (Electron Spin Spectroscopy) measures the transition frequency between different electron spin states. The exchange interaction between the holes and electrons as free delocalized carriers and the localized d spins on the transition metal ions play an important role in the existence of the ferromagnetism in dilute magnetic semiconductors such as $TiO_2$. The magnetic resonance field of the ESR signal can be affected by this exchange interaction, and hence resulted in a Dyson line shape depicted in Figure 6. The Dysonian line shape in ESR spectra obtained in this study reveals the strong exchange interaction between free electrons and localized paramagnetic centers, due to the room temperature ferromagnetism in $TiO_2$. The ESR studies gives the g factor with g = 2. However, it is well known that in hexagonal ferrites the *g*-factor differs greatly from two, and in uniaxial materials it can also be anisotropic under certain conditions [14]. It is inferred that the hole induced ferromagnetism was interpreted as $TiO_2$ to produce diluted magnetic semiconductors.

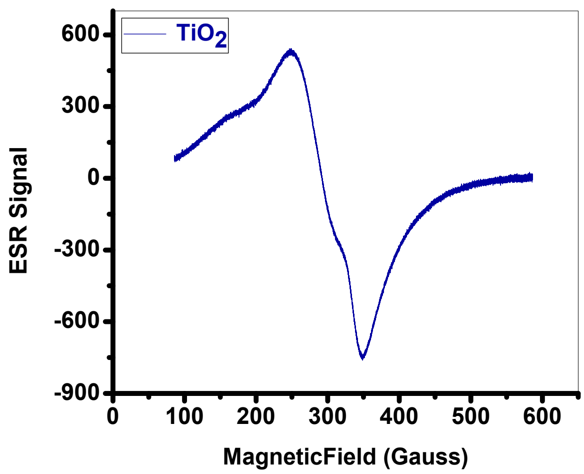


**Figure 6.** ESR Spectra of $TiO_2$.

## 4. Conclusion

$SiO_2$ Nano phosphors were successfully synthesized by sol-gel technique. The crystalline nature was observed in the powder XRD of TiO2 and diffraction peaks belong to rutile and anatase phase of TiO2 and nano particles with an average size between 55.6 and 68.8 nm. The absorption peak at 210 $cm^{-1}$ is observed. It has a wide band gap of 4.5 eV. ESR studies reveals that $TiO_2$ to produce diluted magnetic semiconductors. The Obtained $TiO_2$ nano-powder exhibit good optical properties which is used for device applications.

## 5. Conflicts of Interest

The author(s) declared that they don't have any conflicts of interest.

## 6. Acknowledgements

The authors express their gratitude towards Dr. K.Vijaya Babu, Andhra University, Visakhapatnam, India for PXRD, ESR, FTIR, UV studies. We are grateful to Swarnandhra College of Science & Technology, Narsapur, AP for giving facilities for experiment research.

## 7. References

1 Li W, Ismat Shah S, Huang CP, Jung O, Ni C. Metallorganic chemical vapor deposition and characterization of $TiO_2$ nanoparticles. Materials Science and Engineering: B 2002; 96(3): 247-253.

2 Remillard JT, McBride JR, Nietering KE, Drews AR, Zhang X. Real time in situ spectroscopic ellipsometry studies of the photocatalytic oxidation of stearic acid on titania films. The Journal of Physical Chemistry B 2000; 104(18): 4440-4447.

3 Traversa E. Design of ceramic materials for chemical sensors with novel properties. Journal of the American Ceramic Society 1995; 78(10): 2625-2632.

4 O'Regan B, Grätzel M. A low-cost, high-efficiency solar cell based on dye sensitized colloidal TiO2 films. Nature 1991; 353(6346): 737-740.

5 Kay A, Grätzel M. Low cost photovoltaic modules based on dye sensitized nanocrystalline titanium dioxide and carbon powder. Solar Energy Materials and Solar Cells 1996; 44(1): 99–117.

6 Mahshid S, Askari M, Ghamsari MS. Synthesis of TiO2 nanoparticles by hydrolysis and peptization of titanium isopropoxide Solution. Journal of Material Processing Technology 2007; 189(1-3): 296-300.

7 Plesch G, Gorbar M, Vogt UF, Jesenak K, Vargova M. Reticulated macroporous ceramic foam supportedtio2 for photocatalytic Applications. Materials Letters 2009; 63(3-4): 461-463.

8 Formenti M, Juillet F, Meriiaudeau P, Teichner SJ, Vergnon PJ. Preparation in a Hydrogen-Oxygen Flame of Ultrafine Metal Oxide Particles. Oxidative Properties toward Hydrocarbons in the Presence of Ultraviolet Radiation. Journal of Colloid and Interface Science 1972; 39(1): 79-89.

9 Shi LY, Li CZ, Fang CY. Mater. Rev. (Ch) 1998; 12: 23.

10 Shi L, Li C, Chen A, Zhu Y, Fang D. Materials Chemistry and Physics 2000; 66: 51.

11 Mazdiyasni KS. Powder synthesis from metal-organic precursors. Ceram International 1982; 8: 42.

12 Yan M, Rhodes W, Sprintger L. Bulletin of the American Ceramic Society 1982; 61: 911.

13 Sharmila Devi R, Venckatesh R, Sivaraj R. Synthesis of Titanium Dioxide Nanoparticles by Sol-Gel Technique. International Journal of Innovative Research in Science, Engineering and Technology 2014; 3(8): 15206-15211.

14 Zhuravlev VA. Ferromagnetic resonance in the polycrystalline hexagonal ferrites Co22xZnxW. Physics of solid state 1999; 41(6): 956-959.