Research Article

Journal of Environmental Nanotechnology

Synthesis and Characterization of Poly Ortho Toluidine doped with Commercial TiO_2 Nanoparticle

V. Gayathri, R. Balan*

Department of Physics, Chikkanna Government Arts College, Tiruppur, TN, India
Received: 21.08.2019 Accepted: 25.09.2019 Published: 30-09-2019
*balanphy@yahoo.co.in

ABSTRACT

This work was aimed at the study of the change in the properties of commercial TiO_2 with conducting polymer such as Poly ortho toluidine (POT) synthesized by Oxidative chemical polymerization. The metastable anatase phase of TiO_2 and POT+TiO_2 composites were characterized by using X-Ray Diffraction analysis, Scanning Electron Microscopy and Fourier Infrared Spectroscopy. The bandgaps of the samples were found by UV-Visible spectroscopy.

Keywords: Commercial TiO_2; FT-IR, Poly ortho toluidine; SRD; UV-Vis.

1. INTRODUCTION

Conducting polymers such as polyaniline is considered to be unique due to its excellent electrical and optical properties. Poly aniline have been used in a variety of applications such as corrosion protection, catalysis and sensors because of its non-redox doping, good environmental and thermal stabilities, high conductivity and economic feasibility. The properties of conducting polymer composites depends upon the doping concentration of nanoparticles (Tieli Zhou *et al.* 2015; Kiran Kumari *et al.* 2011). Among conducting polymers poly ortho toluidine (POT) is highly promising and it has better solubility and higher processability by steric hindrance π-electron effects (Gigliola Lusvardi *et al.* 2017). TiO_2 nanoparticles are semiconducting in nature with good photocatalytic activity and they have wide range of applications like cosmetics and air purification. The three types of crystallographic structures of TiO_2 are anatase, rutile and brookite. Among all these phases, rutile is the most stable one where anatase and brookite correspond to metastable and unstable states (Bin Wang *et al.* 2015).

The aim of this work was to study the changed properties of TiO_2 in the presence of POT in the composites. Chemical oxidative polymerization method was used to synthesize POT. The synthesis as well as structural and optical properties of POT doped with TiO_2 nanoparticles were reported. The functional groups of samples were examined by FTIR spectroscopy. The morphological, structural and bandgap analyses of TiO_2 and POT/TiO_2 composites were carried out by SEM-EDX, XRD and UV-Vis. spectroscopy.

2. EXPERIMENTAL DETAILS

2.1 Materials and Method

O-toluidine (99% AR grade, Lobal Chemie Laboratory Reagents and Fine Chemicals), H_2SO_4, Ammonium peroxo disulfate (>98%, Merck), Commercial TiO_2 (98%, Fisher Scientific) and Millipore–Q water were used as received.

POT-TiO_2 composites has been synthesized by chemical oxidative polymerization at room temperature. In this process, an appropriate amount of size reduced TiO_2 was dispersed in 0.2 M of H_2SO_4 by ultrasonication. Then the dispersed TiO_2 solution was added slowly to 0.1 M aqueous solution of O-toluidine with continuous stirring for 30 minutes. 0.1 M aqueous solution of ammonium peroxo disulfate was added dropwise to polymerization bath to initiate the polymerization and the solution was left for 4 hours with continuous stirring; then the solution was kept overnight. The resultant precipitate was filtered and washed several times with acetone followed by water and to be dried at 80 °C in an oven. Finally, dark green colour powder form of POT/TiO_2 composite can be obtained.

3. MATERIAL CHARACTERIZATION

X-ray diffraction data of samples were recorded using an XPERT Diffractometer. The surface morphology and elemental compositions have been investigated by Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray Spectroscopy (EDX). Absorption spectra of the anatase phase of TiO_2 and composites were recorded using UV-Visible Spectrometer (DRS, Analytek Jena, Germany). The functional groups of samples were found by ATR-FTIR, Bruker, Germany.

4. RESULTS AND DISCUSSION

4.1 X-ray diffraction analysis

The XRD characteristic peaks at 25°, 31° and 37°, as shown in Fig. 1 (a), represented the anatase phase of TiO_2 corresponding to (101), (004) and (200) planes. The XRD spectra of POT+TiO_2, shown in Fig. 1 (b), was similar to that of pure TiO_2, revealing that the crystalline phase of TiO_2 was not altered by POT. The only difference observed was the intensity of diffraction peaks of POT+TiO_2 composites was slightly lesser than that of pure TiO_2 due to the amorphous nature of POT in the composites.

4.2 Morphological analysis

The morphology of pure TiO_2 and POT+TiO_2 were examined by SEM. From the SEM micrographs of TiO_2 nanoparticles shown in Fig. 2 (a), it was evident that they were spherical in shape whereas, Fig. 2 (b) revealed the flake-like feature with globular structure of POT interlinked with TiO_2 nanoparticles which confirmed the formation of composites. Fig. 3 (a and b) shows the elements corresponding to TiO_2 and POT+TiO_2 composites, respectively.

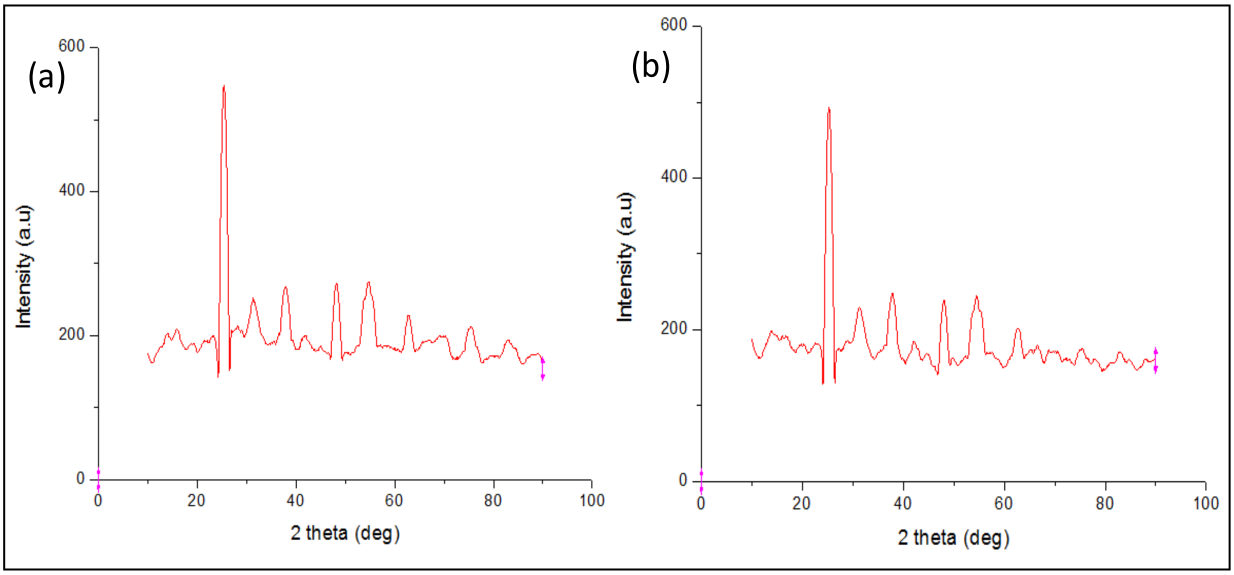

Fig. 1: XRD spectra of (a) TiO_2 nanoparticle and (b) POT + TiO_2 composites

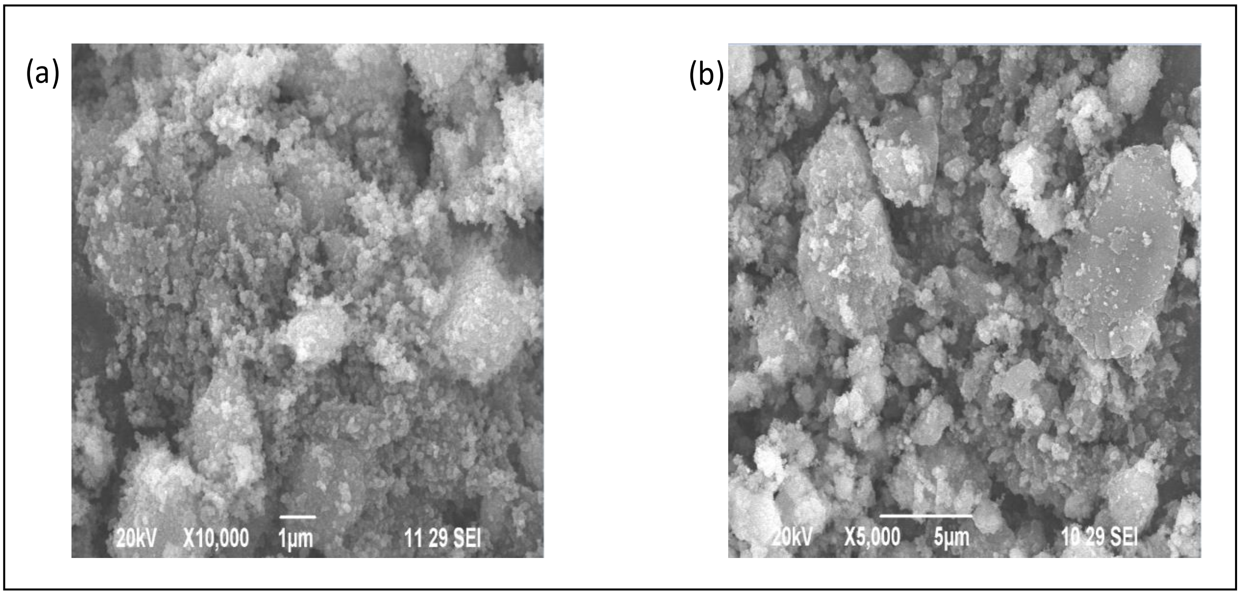

Fig. 2: SEM images of (a) TiO_2 nanoparticles and (b) POT + TiO_2 composites

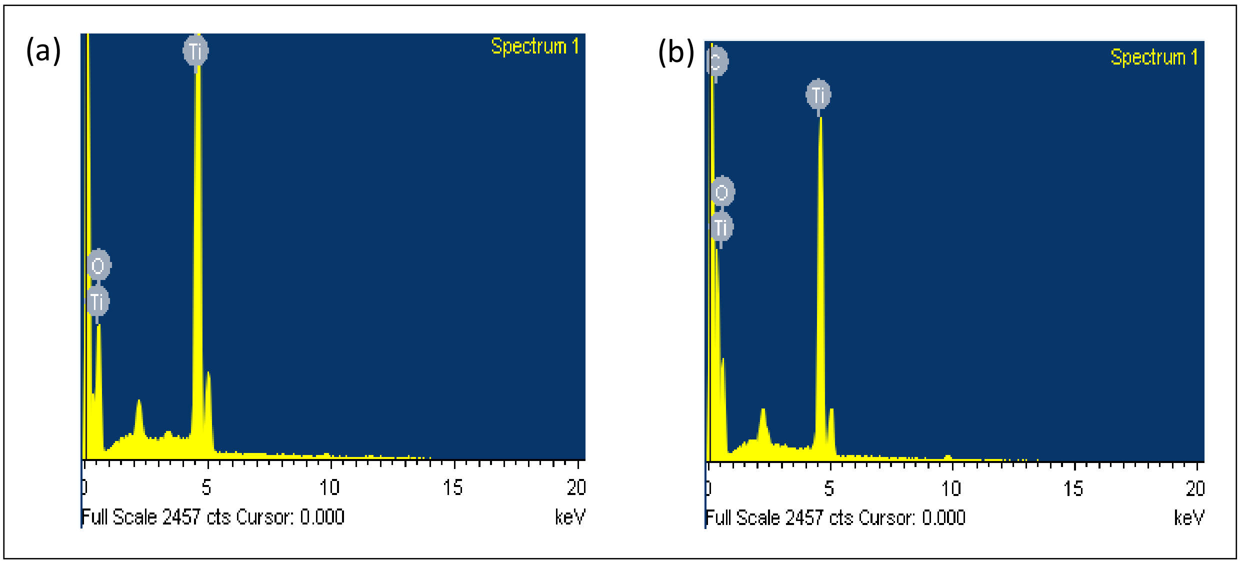

Fig. 3: EDX spectra of (a) TiO_2 nanoparticles and (b) POT + TiO_2 composites

4.3 UV-Vis. Spectroscopy

From UV-Vis. spectra shown in Fig. 4 (a and b), the absorbance of TiO_2 and POT+TiO_2 composites were about 344 nm and 334 nm, respectively. The absorbance of composites was slightly shifted to a lower wavelength indicating the dispersion of TiO_2 in the composites. The bandgap of pure TiO_2 and POT+TiO_2 can be calculated by using the formula E = hγ. The bandgap value of composites is 3.7 eV which is greater than pure TiO_2 (3.6 eV).

4.4 FOURIER INFRARED SPECTROSCOPY

In Fig. 5 (a and b) shows the FTIR spectra of pure TiO_2 and POT+TiO_2 composites. The characteristic peaks at 3749 cm^{-1} and 604 cm^{-1} indicated the Ti-O-Ti and O-H stretching frequencies (Asha *et al.* 2014). The intensity of characteristic peaks corresponding to composites were somewhat similar to that of pure TiO_2 with additional peaks at 3619 cm^{-1} corresponding to the N-H stretching of an aromatic amine, confirming the formation of POT in the composites (Borriello *et al.* 2011). The peaks observed at 1494 cm^{-1} in composites corresponded to C-N stretching vibrations of quinoid and benzenoid rings (Canon Uchoyuk *et al.* 2012).

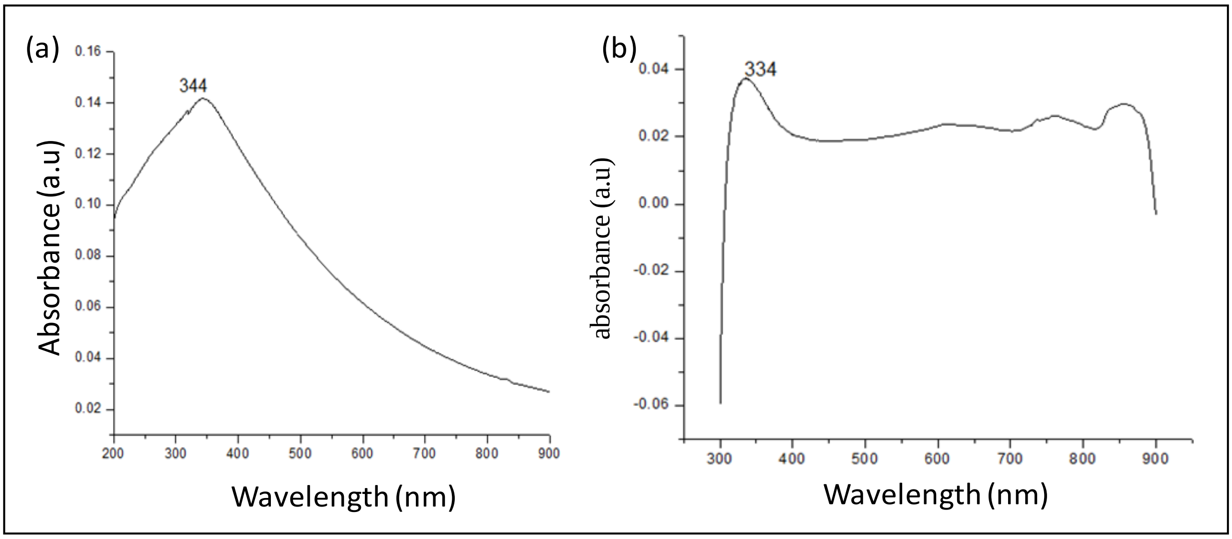

Fig. 4: UV-Visible spectra of (a) TiO_2 nanoparticles and (b) POT + TiO_2 composites.

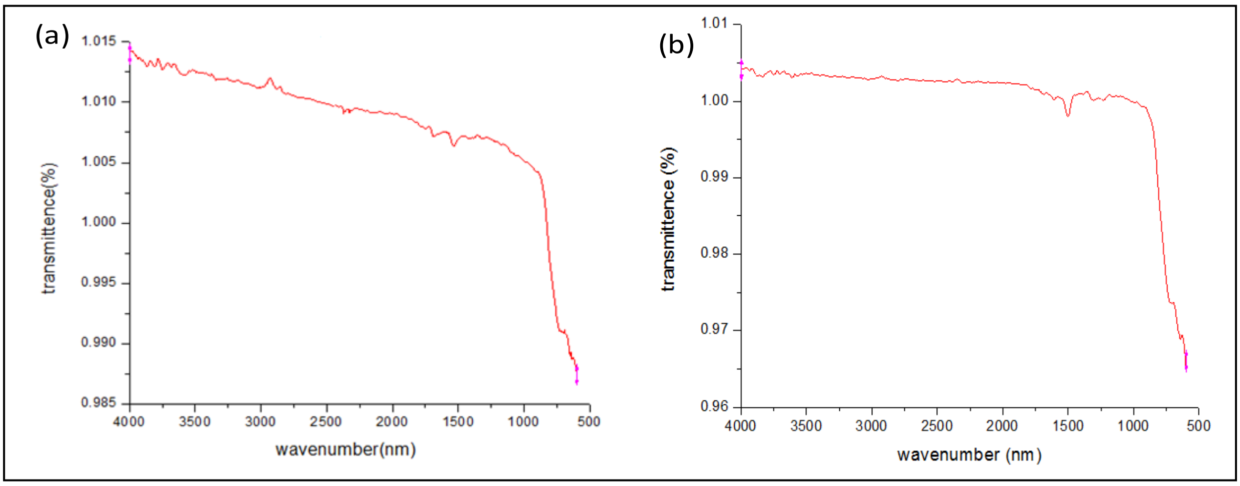

Fig. 5: FT-IR spectra of (a) TiO_2 nanoparticles and (b) POT + TiO_2 composites

5. CONCLUSION

The change in properties of TiO_2 due to poly ortho toluidine, synthesized by the chemical oxidative polymerization method was examined. XRD studies have shown that the crystalline structure of anatase TiO_2 with the amorphous nature of poly ortho toluidine confirmed the formation of composites with lesser intensity. The functional groups and spherical morphology of TiO_2 interlinked with poly ortho toluidine were examined by FT-IR and SEM-EDX. UV-Visible spectroscopic results have shown that POT+ TiO_2 composites exhibited a higher bandgap when compared to pure TiO_2.

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.

REFERENCES

Asha, Sneh Lata Goyal, Kumar. D, Shyam Kumar and Kishore, Nn., Synthesis and characterization of polyaniline/TiO_2 composites, *Indian J. Pure Appl. Phys.*, 52(2), 341-347 (2014).

Bin Wang, Hongji Qi, Hu wang, Yanyan Cui, Jiaoling Zhao, Jialu Guo, Yun Cui, Youchen Liu, Kui Yi and Jiando Shao, Morphology, structure and optical properties in TiO_2 nanostructured films annealed at various temperatures, *Opt. Mater. Express*, 5(6), 1410-1418 (2015). https://dx.doi.org/10.1364/OME.5.001410

Borriello, A., Guarino, V., Schiavo, L., Alvarez Perez, M. A. and Ambrosio, L., Optimizing PANi doped electroactive substrates as patches for the regeneration of cardiac muscle, *J. Mater. Sci. Mater. Med.*, 22(4), 1053-1062 (2011). https://dx.doi.org/10.1007/s10856-011-4259-x

Canon Uchoyuk, Meral Karakisla and Mehmet Sacak., Preparation of Poly (o-toluidine) / Polyacrylonitrile composite fibers using CrO_3, *Indian J. Fiber Text. Res.*, 37(2), 120-126 (2012).

Gigliola Lusvardi, Corrado Barani, Federica Giubertoni, Giulia paganelli.: Synthesis and characterization of TiO_2 nanoparticles for the reduction of water pollutants, *Mater.*, 10(10), 1208-1218 (2017). https://dx.doi.org/10.3390/ma10101208

Kiran Kumari, Vazid Ali, Gita Rani, Sushil Kumar, Lakshmi, G. V. B. S. and Zolfequar, M., DC conductivity and spectroscopic characterization of poly (o-toluidine) doped with binary dopant $ZrOCl_2$/AgI, *Int. J. Mater. Sci. Appl.*, 2(8), 1049-1057 (2011). https://dx.doi.org/10.4236/msa.2011.28142

Tieli Zhou, Xiuhong Xie, Jianyan Cai, Liying Yin and Weidong Ruan, Preparation of Poly (o-toluidine) / TiO_2 nanocomposite films and application for humidity sensing, *Polym. Bull.*, 73(3), 621-630 (2015). https://dx.doi.org/10.1007/s00289-015-1509-y