Structural and Morphological Properties of Titanium Dioxide Nanoparticles Doped with Zinc

Curtis Milligan, George Boktor, Dr. Suman Neupane

Department of Physics and Astronomy

ABSTRACT

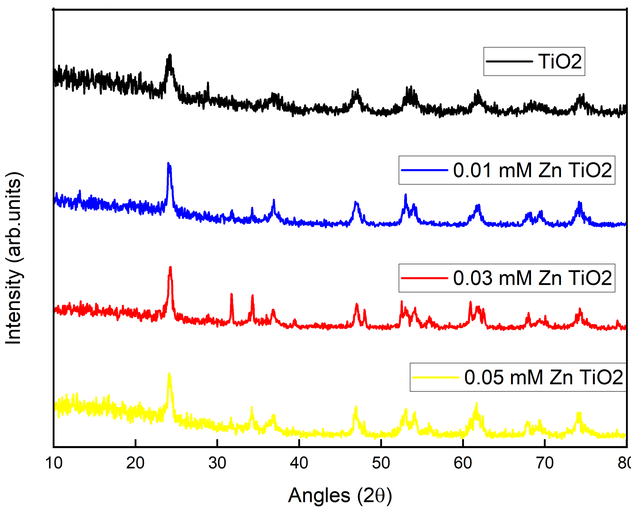
Titanium Dioxide (TiO_2) nanoparticles are commonly used for their photocatalytic properties[1-3]. The photoactivity of TiO_2 is reported to be at its highest at the {001} planes of anatase, but {101} planes are more stable and thus more commonly produced. We have analyzed the effect of zinc doping on structural and morphological properties of TiO_2 nanoparticles. Based on the scanning electron microscope images, the introduction of zinc caused the formation of smaller nanoparticles. The X-ray diffraction measurements shows the formation of crystalline particles and the effect of zinc incorporation. The doping of TiO_2 is to measure how the inclusion of other materials may enhance or inhibit its photocatalytic effects for usage in various things such as hydrogen generators or as a cleaning agent for industrial waste dye.

EXPERIMENTAL METHODS

The material synthesis is similar to the process described in earlier reports[4]. One approach is to add 1%, 3%, or 5% Zinc oxide to pure TiO_2 nanoparticles dissolved thoroughly in ethanol. Water soluble reducing agent was like LiOH can be added prior to annealing in air at temperatures around 900 °C. The crystallinity of the sample was determined by X-ray diffraction studies. The surface morphology of these structures were determined by scanning electron microscopy.

RESULTS

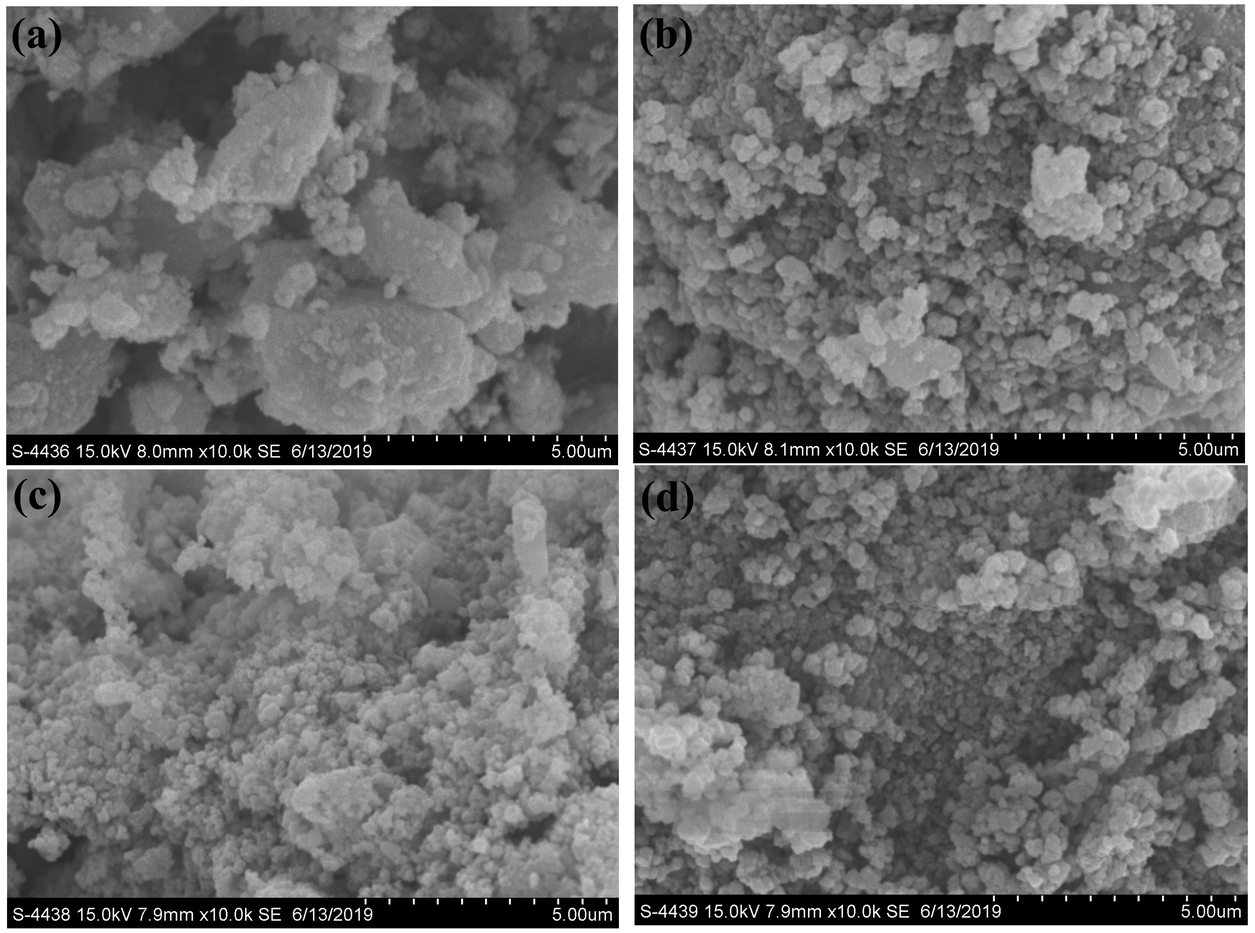
X-ray diffraction studies



The XRD peaks of Zn doped TiO_2 show additional peaks at 32°, 34°, and 38° due to contributions from ZnO. This confirms the crystallinity and successful doping of zinc in our samples.

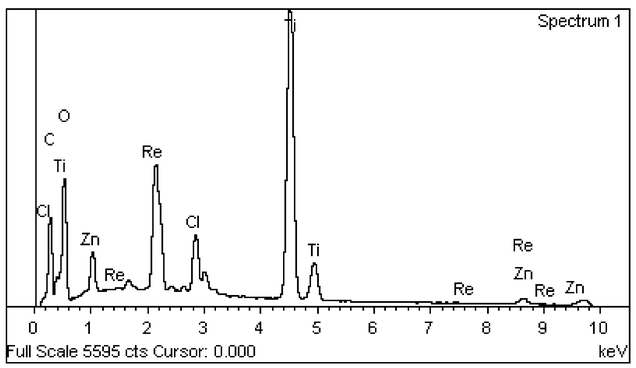
RESULTS

Scanning electron microscopy images



Scanning electron microscopy images (a) Pristine TiO_2 (b) 0.01 mM Zn-doped TiO_2 (c) 0.03 mM Zn-doped TiO_2 (d) 0.05 mM Zn-doped TiO_2. Incorporation of zinc of different concentration led to the drastic change in structure of TiO_2 nanoparticles. With the increase in the Zn concentration, the particle size reduced significantly.

Elemental Distribution Spectrum



Element	Weight%	Atomic%
C K	13	25
O K	35	51
Ti K	45	22
Zn L	7	2
Totals	100.00	

CONCLUSIONS

We have successfully doped different amount of zinc on TiO_2 nanoparticles using a novel technique. X-ray diffraction analysis shows sharp-peaked patterns confirming the high crystallinity of samples. Doping zinc into TiO_2 nanoparticles resulted in additional peak which can be related with standard zinc compounds. The scanning electron microscopic images reveal the agglomeration of regularly shaped nanoparticles throughout the specimen. Nanostructures offer high surface area to volume ration and are highly sought after for the absorption of photons during photovoltaic applications.

The energy dispersive spectroscopic analysis show the contributions from doped zinc in addition to elemental titanium and oxygen atoms. The ultraviolet-visible spectroscopic analysis shows that these materials have high absorption in the ultraviolet region. Such materials find application in solar cells with high efficiency.

REFERENCES

1. Jing et. al. , J. Phys. Chem. B **2006,** 110, 17860-17865
2. Shivaraju et. al., Appl Water Sci (2017) 7:3937–3948
3. Garadkar et. al., Mat. Sci. Res. India, Vol. **15**(3), pg. 197-208 (2018)
4. John et. Al, Nano-Micro Lett. 4 (2), 65-72 (2012)

ACKNOWLEDGMENTs

SN also acknowledges MTSU Interdisciplinary Microanalysis and Imaging Center (MIMIC) and Ms. Joyce Miller for electron microscopy.

MIDDLE TENNESSEE STATE UNIVERSITY