

**GREEN SYNTHESIS AND CHARACTERIZATION OF TITANIUM  
DIOXIDE-SILICA COMPOSITE ELECTRODE FOR DYE-SENSITIZED  
SOLAR CELL**

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**JULY, 2024**

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SOLAR CELL**

**BY**

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**A DISSERTATION SUBMITTED TO THE SCHOOL OF  
POSTGRADUATE STUDIES IN PARTIAL FULFILMENT OF THE  
REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER  
OF SCIENCE (M.Sc) IN INDUSTRIAL PHYSICS (RENEWABLE  
ENERGY AND MATERIAL SCIENCE) IN THE DEPARTMENT OF  
PHYSICS, COVENANT UNIVERSITY, OTA, OGUN STATE, NIGERIA**

**JULY, 2024**

## **ACCEPTANCE**

This is to attest that this research work is accepted in partial fulfillment of the requirements for the award of the degree of Master of Science (M.Sc.) in Industrial Physics (Renewable Energy and Material Science) in the Department of Physics, College of Science and Technology, Covenant University, Ota, Ogun State, Nigeria.

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**Signature and Date**

## **DECLARATION**

I, **JAMES, UTIBE ETOP (16CE021673)** declare that this research was carried out by me under the supervision of Dr. Rasidi Sule of the Department of Physics, College of Science and Technology, Covenant University, Ota, Nigeria. I attest that this dissertation has not been presented wholly or partially for the award of any degree elsewhere. All sources of data and scholarly information used in this dissertation are duly acknowledged.

**JAMES, UTIBE ETOP**

**Signature and Date**

## CERTIFICATION

We certify that this dissertation titled “**GREEN SYNTHESIS AND CHARACTERIZATION OF TITANIUM DIOXIDE-SILICA COMPOSITE ELECTRODE FOR DYE-SENSITIZED SOLAR CELL**” is an original research work carried out by **JAMES, UTIBE ETOP (16CE021673)** in the Department of Physics, College of Science and Technology, Covenant University, Ota, Ogun State, Nigeria under the supervision of Dr. Rasidi Sule. We have examined and found this work acceptable as part of the requirements for the award of the degree of Master of Science in Industrial Physics (Renewable Energy and Material Science).

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**Signature and Date**

## **DEDICATION**

I would like to dedicate this research to the Almighty God for His grace and the wisdom and assistance to follow through with this program.

## ACKNOWLEDGEMENTS

I express my deepest gratitude to God Almighty for the grace and enablement upon my life to see this program to the end. I appreciate the Chancellor of Covenant University, Dr. David O. Oyedepo and the Vice Chancellor, Professor Humphrey A. Adebayo and the entire management team of Covenant University. I am grateful to the Dean of the School of Postgraduate Studies, Professor Akan B. Williams and to the Dean of the College of Science and Technology, Professor Timothy A. Anake. I appreciate my Head of Department, Professor Mojisola R. Usikalu for her constructive criticisms, contributions and suggestions throughout this work resulting in the timely completion of this program.

I am grateful to my supervisor, Dr. Rasidi Sule, for his invaluable guidance, and unwavering support whose insights have been instrumental in shaping this research, and I am deeply grateful for the time and effort you have invested in me. I am grateful to Prof. M. L. Akinyemi, Prof. A. P. Aizebeokhai, Dr. T. A. Adagunodo, Dr. K. D. Oyeyemi, Dr O. C. Olawole, Dr. S. A. Akinwunmi, Dr. O. R. Jolayemi, Dr. A. E. Duke, and Mr. T. Arijaje for their encouragement and guidance. I want to thank all the members of the Department of Physics, Faculty, Staff, and students who have supported and guided me throughout the completion of this research project. A special thank you to the Department of Chemical Engineering, Department of Biochemistry, and Department of Chemistry for access to your facilities which has enriched my research experience. I would like to thank Engr. O. A. Adegbite and Mr A. O. Adeyemi for your technical support. To my parents and beloved brother, AIG Etop James, Mrs. Crystal James, and Mbuotidem James, I thank you for your encouragement, and sacrifices, and for always believing in me. Your provision and emotional support before, during and after this project is well appreciated. This journey would have been cut short without the support and encouragement of every one of you.

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## **ABBREVIATIONS**

BET: Brunauer-Emmett-Teller Surface Area

DSSC: Dye-Sensitized Solar Cell

FTIR: Fourier Transform Infrared Spectroscopy

PV: Photovoltaic

SEM: Scanning Electron Microscopy

SiO<sub>2</sub>: Silicon Oxide (Silica)

TiO<sub>2</sub>: Titanium Dioxide

TTIP: Titanium Tetra Isopropoxide

UV-Vis: UV-Visible Spectroscopy

XRD: X-Ray Diffraction

XRF: X-Ray Fluorescence

## ABSTRACT

The adverse effects of climate change have necessitated the need for a reduction in traditional synthetic chemicals used for synthesizing useful materials which have been found to impact the environment negatively. Biosynthesis of Titanium dioxide ( $\text{TiO}_2$ ) has been gaining scientific attention recently due to its environmentally friendly nature. The unique properties of  $\text{TiO}_2$  have made it a suitable material for dye-sensitized solar cell (DSSC) electrodes. However, about 4% of solar irradiation under the ultraviolet range gets absorbed due to the large bandgap of  $\text{TiO}_2$ . Since electron-hole pairs can occur for  $\text{TiO}_2$  at UV light, it is important to extend the light absorption of  $\text{TiO}_2$  to the visible light by modifying  $\text{TiO}_2$  with silica. Titanium dioxide ( $\text{TiO}_2$ ) was successfully synthesized using aloe vera plant extract at varying concentrations (50, 70, and 100 ml). The silica used for the  $\text{TiO}_2$ -silica composite was produced from rice husk. The synthesised materials were characterized by UV-visible spectroscopy, X-ray diffraction (XRD), Fourier Transform Infrared (FTIR) Spectroscopy, Scanning Electron Microscopy (SEM), X-ray fluorescence (XRF), and Brunauer-Emmett-Teller (BET) Surface Area. The electrochemical method was used to examine the photoactivity of  $\text{TiO}_2$  and  $\text{TiO}_2$ -silica composite under light and dark conditions. The band gap of as-synthesized  $\text{TiO}_2$  containing 50, 70, and 100 ml of aloe vera extract was found to be 3.96 eV, 3.99 eV and 3.96 eV respectively. The addition of silica reduced the band gap of  $\text{TiO}_2$  from 3.96 eV to 3.0 eV. The XRD analysis revealed a pure tetragonal anatase phase of  $\text{TiO}_2$ . The FTIR showed that the absorbance peak at  $792.72\text{ cm}^{-1}$  corresponded to the Ti-O-Ti bond of anatase  $\text{TiO}_2$  while the Si-O-Si bond for silica was found at  $797.7\text{ cm}^{-1}$ . The SEM image shows the needle-like shape of as-synthesized  $\text{TiO}_2$ . The XRF results showed that over 80 wt.%  $\text{TiO}_2$  was produced, and 94 wt.% of silica was derived from rice husk. The BET surface area of as-synthesized mesoporous  $\text{TiO}_2$  was found to be  $214.34\text{ m}^2/\text{g}$  while that of silica was  $222.83\text{ m}^2/\text{g}$ . The large surface area obtained for  $\text{TiO}_2$ , and silica will enable the material to absorb photons effectively which would enhance the efficiency of the electrode. The electrochemical results revealed that the  $\text{TiO}_2$  produced is photoactive. The results obtained suggested that silica has the potential to be used as a solar cell electrode when incorporated with  $\text{TiO}_2$ . This research reveals that aloe vera plant and silica from unutilized rice husk could be explored for energy sustainability which align with the Sustainable Development Goal for affordable and clean energy.

***Keywords: Dye-Sensitized Solar Cell,  $\text{TiO}_2$ , Green Synthesis, Composite, Characterization, Electrochemical***