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

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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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(Secretary, School of Post Graduate Studies) **Signature and Date**

Prof. Akan B. Williams
(Dean, School of Postgraduate Studies) **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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(External Examiner) **Signature and Date**

Prof. Akan B. Williams
(Dean, School of Postgraduate Studies) **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.

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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_2: Silicon Oxide (Silica)

TiO_2: 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 (TiO_2) has been gaining scientific attention recently due to its environmentally friendly nature. The unique properties of TiO_2 have made it a suitable material for dye-sensitized solar cell (DSSC) electrodes. However, about 4% of solar irradiation under the ultraviolent range gets absorbed due to the large bandgap of TiO_2. Since electron-hole pairs can occur for TiO_2 at UV light, it is important to extend the light absorption of TiO_2 to the visible light by modifying TiO_2 with silica. Titanium dioxide (TiO_2) was successfully synthesized using aloe vera plant extract at varying concentrations (50, 70, and 100 ml). The silica used for the 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 TiO_2 and TiO_2-silica composite under light and dark conditions. The band gap of as-synthesized 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 TiO_2 from 3.96 eV to 3.0 eV. The XRD analysis revealed a pure tetragonal anatase phase of TiO_2. The FTIR showed that the absorbance peak at 792.72 cm^{-1} corresponded to the Ti-O-Ti bond of anatase TiO_2 while the Si-O-Si bond for silica was found at 797.7 cm^{-1}. The SEM image shows the needle-like shape of as-synthesized TiO_2. The XRF results showed that over 80 wt.% TiO_2 was produced, and 94 wt.% of silica was derived from rice husk. The BET surface area of as-synthesized mesoporous TiO_2 was found to be 214.34 m^2/g while that of silica was 222.83 m^2/g. The large surface area obtained for 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 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 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, TiO_2, Green Synthesis, Composite, Characterization, Electrochemical