NJP

# UV-VIS SPECTROPHOTOMETER ANALYSIS OF FILM GROWN USING NATURAL DYE FROM LAWSONIA INERMIS (HENNA PLANT)

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**ABSTRACT**

The films were grown on the substrate using natural dye extracted from Henna plant with water extraction method. The dye was prepared using five grams (5g) of Lawsonia Inermis (Henna Plant) and the mixture of water and methanol 60ml (50:50 ratios). The five grams (5g) of leave and 60ml of mixed measured solvent was grinded for five minutes. The dyes solution extracted were centrifuged at a speed of the revolution centrifugation per minute of 3000rpm to separate the solid fragment from the solution using centrifugation filtering machine. The films were sensitized using the dye and the performance of this dye was carefully examined on the fluorine doped tin oxide film. The films were studied for its optical properties using Spectrophotometer system – UV 752 Axion Medical Ltd Uk, Solar simulator, model 4200-scs semiconductor characterization system was used to studied the power voltage characterization of the grown films while the Tauc model was used to obtain the optical energy band gap of 3.50 *eV*. The transmittance spectrum was shown, while the nature of the Absorbance of Dyed $TiO_2$ was studied**.** The behavior of the Absorption Coefficient of Dyed $TiO_2$ was also investigated. The Current/Voltage and power/voltagePerformances of $TiO_2$-based DSSCs using Lawsonia inermis (Henna plant) plant natural dye extracts was investigated and the solar simulation result of DSSCs developed in this research are listed as follows; ($I_{sc}$) = (0.242 mA), ($V_{oc}$) = 0.375 V, FF(%) = 50.89%, and MPPT |Mw| = 0.046 Mw for Henna dyed $TiO_2$, while the conversion efficiency ɳ (%) of the dye sensitized solar cell was 0.046%.

**Keywords**: Methanol, Centrifugation, Sensitized, Solar-simulation, Power Voltage and Spectrophotometer.

## INTRODUCTION

Researches have revealed that organic dyes absorbs incident energy beyond ultraviolet region of the spectrum. The optical properties of Nanostructural materials have been of great interest as catalysts and other applications because of their unique textural and structural characteristics ((Okoye *et al*., 2021), (Al-Rawashdeh *et al*., 2018), (Ananthakumar *et al*., 2019), (Nwokoye and Okoye, 2020), (Andery *et al*., 2014), (Macht *et al*., 2002), (Brian *et al*., 2009)). The scientists are making every effort to find a way of increasing the amount of incident energy absorbed by the DSSC. Nanocrystalline titanium dioxide ($TiO_2$) soaked in natural dye absorbs incident energy beyond ultraviolet region ((Okoye, 2020), (Calogero and Di-Marco, 2008), (Calogero*et al*., 2010), (Gerrit, 2019), (Hug, *et al*., 2013), (Ugwu *et al*., 2015), (Kabirad *et al*., 2019), (Ekanayake *et al*., 2015), (Ozuomba *et al*., 2011), (Murakoshi *et al*., 1997), ( Okoli *et al*., 2010), (Ezenwa and Ekpunobi, 2010)). Therefore, knowing the type of catalytic and optical properties possessed by each type of $TiO_2$ and natural dye used for the sensitization of grown films `is very important because this will reveal the electrical characteristics/efficiency of the cells before fabrication in a commercial quantity (Macht *et al*., 2002), (Andualem and Demiss, 2018), (Brian *et al*., 2009), (Matt-Law, 1996), (Lee and Kang 2010)). This act has drawn much attention for research because of its wide range of applications in science and technology. Various methods have been adopted on how to deposit titanium dioxide ($TiO_2$) paste or precursor used in fabricating films. In this research, we reported the optical properties of precursors and deposition of nitrogen gas using; chemical vapour deposition method (CVD) and that of titanium dioxide ($TiO_2$) paste using screen printing method. The aim of this work is to study the UV-VIS Spectrophotometer analysis of film grown using natural dye from lawsonia inermis (Henna Plant).

## EXPERIMENTAL PROCEDURES

### Preparation of LawsoniaInermis (Henna Plant) Local Dye

The local dye used in sensitizing the nanocrystalline dyed $TiO_2$ film was extracted from Lawsonia inermis (Henna Plant) which is a common plant in Nigeria. The plant was well blended and the green pigment was extracted using the prepared solvent (50:50 ratios of water and methanol).

**Electrode Deposition**

Flourine Doped Tin Oxide (FTO) thin films were deposited on the soda lime glass substrates (Axion Medicals UF) via Chemical Vapour Deposition (CVD) method. Sixty (60%) of Tin (IV) Chloride ($SnCl_4$) and forty (40%) of hydrofluoric acid was deposited on the cleaned soda lime glass as precursors and Nitrogen gas was used as a carrier gas. Nitrogen gas was fed from a cylinder through a pressure regulator (Glook scientific) set at 0.5 Bars and then through a mass flow controller (Alicat Scientific). The flow rate is set at one (1) Liter per minute and then through a bubbler containing $SnCl_4$ (anhydrous).

A separate gas stream at one (1) Liter per minute is bubbled through the hydrofluoric acid precursor.

The two gas streams converge on the substrate maintained at $550^0$C by means of a thermocouple and temperature controller (Rex C-900).

A chemical reaction takes place leading to the deposition of a transparent and conductive FTO thin film. The deposition time is varied between one minute and 5 minutes to generate films of transparent and conductive layers. FTO generate films of different conductivities and transparency.

**Deposition of Titanium Dioxide Paste ($TiO_2$) on the Soda Lime Glass**

The $TiO_2$ used for this study was purchased from solaronix Shop in Abuja, $TiO_2$-Titanium dioxide z/sp 100g. Titanium dioxide paste ($TiO_2$) was deposited on the previously prepared FTO substrate and blocking layer grown film. Firstly, in order to form mesoporous layer on the substrate, the portion to be coated was placed under the square dimension marked on the screen cap of the printer. Thereafter, the substrate was firmly held with masking tape. The printing cover of the screen printer (cap) was gently released to enable contact with the surface of the substrate placed inside the square dimension unit marked under the printers cap. The printing was performed on the conducting side of the substrate. After screen printing $TiO_2$ on the substrate, the substrate was dried and annealed at 500ºC for the period of 30 minutes to allow the $TiO_2$ settle well and absorbed on the substrate. After annealing, $TiO_2$ was deposited for the second time using screen printing method to increase the thickness of the cell from 7 microns to 14 microns.

**Thermal Annealing**

The nanocrystalline lawsonia inermis dyed $TiO_2$ electrode was allowed to dry naturally for about 30 minutes in air. The adhesive tapes were then removed and the edges were cleaned with ethanol. With the use of an electric hot plate, the film was subjected to thermal annealing at 550ºC for 30 minutes and the electrode was sintered for about 30 minutes at 550ºC using thermocouple and temperature controller.

**Sensitization Impregnation**

The thermally treated electrode was immersed overnight into a solution of the Lawsonia inermis (Henna Plant) dye. The electrode was soaked in dyes for 12 hours to form another layer on top of M-$TiO_2$ layer. Thereafter, the substrate was rinse with water and dried at 50ºC. The presence of dye on the substrate allowed the cell to absorb photon energy even in the infrared region of the spectrum (low light condition). The presence of dye in a cell allow the cell to sense and absorb photon energy that shines on the room and environments.

**3.0 RESULT AND DISCUSSION**

**Spectroscopic Results**

Figure 1 is the UV-visible spectroscopy result for liquid and solid sample of Henna dye.

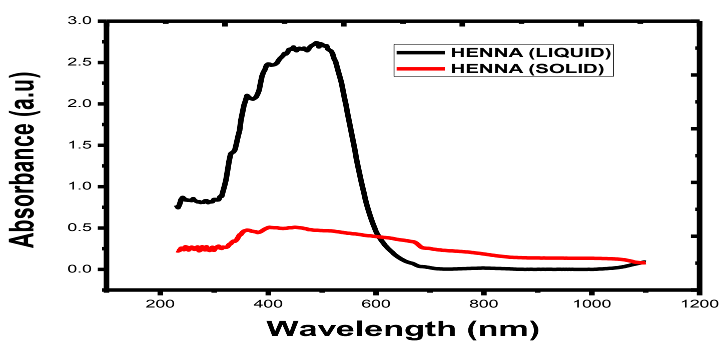


**Figure 1:** The plot of absorbance as a function of wavelength for Henna (liquid and solid sample)

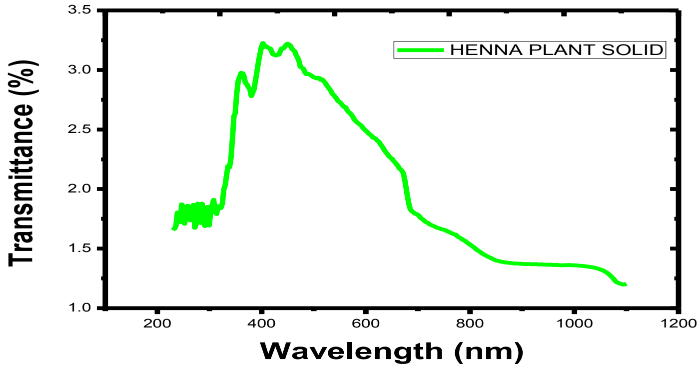


**Figure 2:**The plot transmittance (%) as a function wavelength for henna plant

Figure.1.0 is the spectra lines of the absorbance values of the dyes while Fig. 2 is the transmittance lines of the same samples. The graph was plotted using origin software. The absorbance values fall within the range of 230-1100nm. The plot shows that the transmittance increases as the wavelength of incident radiation increase. The transmittance of above 56% in the infrared region and transmittance of blow 45% in the ultraviolet region was recorded. Films of low transmittance in the infrared region is used in the mass production of solar cells and for the fabrication of solar panel while films with high transmittance in the ultraviolet region is useful in photosynthetic coatings because they exhibit selective transmittance of photosynthetic active radiation (PAR) and also used as reflector and dielectric filter (Okoye*et al*., 2021).

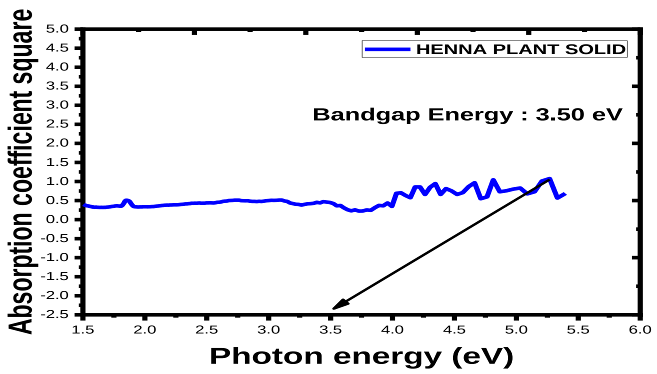


**Figure 3:** The plot of absorption coefficient square as a function photon energy Henna plan

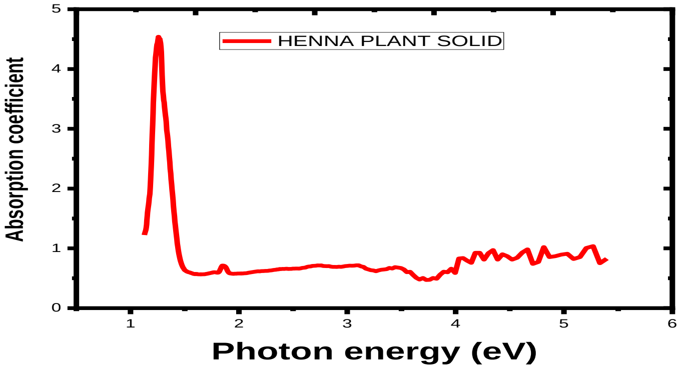


**Figure 4:** The plot of absorption coefficient as a function of photon energy for Henna plant solid

Based on the Percentage of Transmittance obtained from UV-Vis Spectrophotometer, Absorbance of Henna Plant dyed $TiO_2$ were obtained according to the equation, $A = 2 - log_{10}\%T$; where A is defined as absorbance and T as transmittance. The Energy band gap graphs and Absorption Coefficient graph were shown in Figures 3-4.

### Optical Analysis for the Solid Samples on Fluorine Doped Tin Oxide

### Absorbance as a Function of Wavelength for Henna Plant Synthesized on FTO

Optical analysis for the grown films of dyed $TiO_2$ was carried out; Figure 1 show the plot of absorbance against wavelength for the solid and liquid samples. It was observed that as the wavelength of the incident radiation increases the absorbance of the film radiation decreases from the UV, and infrared region. The Henna recorded a steady absorbance in both regions. This high absorbance in the UV region makes Henna Plant useful in p-n junction formation of solar cells with other suitable thin film materials for photovoltaic applications, while the low absorption of Henna Plant in the infrared makes it useful for the mass production of solar cells and for the fabrication of solar panel.

## CONCLUSSION

Thin film of sol-gel extracted from Lawsonia inermis (Henna Plant) dyed $TiO_2$ was succefully deposited onto an FTO substrate through the CVD and screen-printing method. The film was subjected to thermal treatment and then doped with a local dye extracted from Lawsonia inermis (Henna Plant). Optical analysis of dyed for the grown films were carried out using UV-visSpectrophotometer system – Uv 752 Axion Medical Ltd Uk. These shows that the sensitized titanium dioxide electrode could absorb light both in the ultraviolet and visible region. Using the Tauc model, the optical band gap of the dyed $TiO_2$ was found to be 1.49ev which is lower than the band gap of the three crystal structures in $TiO_2$. Therefore, the Lawsonia inermis (Henna Plant) dye can be used as photosensitizer for wide band gap semiconductors such as $TiO_2$ which alone cannot absorb visible light. The photo-conversion efficiency of a dye sensitized solar cell fabricated with the doped nanocrystalline titanium (iv) oxide was 0.046%.

## REFERENCES

Okoye, I. F., Nwokoye, A.O.C. and Ahmad, G. (2021).Power Voltage Characteristics of Fabricated Dssc Incorporating Multiple Organic Dyes as Photo-sensitizer, Energy and power engineering, Vol.13 No. 6: 221-235.

Al-Rawashdeh, N.A.F., Albiss, B.A. and Yousef, M.H.I. (2018). Graphene-Based Transparent Electrodes for Dye Sensitized Solar Cells. IOP Conf. Ser. Mater. Sci. Eng., 012019:305.

Ananthakumar, S., Balaji, D., Ram, K., and Sridharan, M.B. (2019). Role of co-sensitization in dye-sensitized and quantum dot-sensitized solar cells.

Nwokoye, A. O. C. and Okoye, I. F. (2020).Profilomatry Analysis of Flourine Doped Tin Oxide (FTO) Film and the Semiconductor Properties of Organic Dye FromSenna Plant as a Photosensitizer, Der ChemicaSinica., 11(1): 2.

Andery, L., Noramaliyana, H.M., Kushan, T., Chandrakanthi, R.L., Linda, B.L., Sarath, B. and Piyasiri, E. (2014).Higher Performance of DSSC with Dyes from Cladophora sp. As Mixed Cosensitizer through Synergistic Effect. Hindawi Publishing Corporation, Journal of Biophysics.

Macht, B., Turrión, M,,Barkschat, A., Salvador, P., Ellmer, K. and Tributsch, H. (2002). Patterns of efficiency and degradation in dye sensitization solar cells measured with imaging techniques. Solar Energy Materials and Solar Cells, Volume 73: 163-173.

Brian, E.H., Eric, T.H., Paul, B.A., Jun-Ho, Y., Pascal, C., Toma′s, T., Jean, M. J., Khaja, N., Michael, G. and Michael, D.M. (2009). Increased light harvesting in dye-sensitized solar cells with energy relay dyes.

Okoye, I. F (2020).Basic Applications in Energy and Power. Ahmadu Bello University Publisher and Press Limited, Zaria, Kaduna State, Nigeria.

Calogero, G, and Di-Marco, G. (2008).Red sililian orange and purple eggplant fruits as natural sensitizers for dye-sensitized solar cells, *J. Solar Energy Mater,* 92, 1341-1346.

Calogero, G., Di-Marco, G., Cazzanti, S., Caramoni, S., Argazzi, R., Carlo, A.D. and Bignozzi, C.T. (2010). Efficient dye-sensitized solar cells using red turnip and purple wild sicilian prickly pear fruits, *Int. Journal Mol. Sci.,* 11, 254-267.

Gerrit, B. (2019). Improving the Performance of Dye-Sensitized Solar Cells. Journal of Physical Chemistry and Chemical Physics.

Hug, H., Bader, M, Mair. P. and Glatzel, T. (2013). Biophotovoltaics: Natural pigments in dye-sensitized solar cells, J of Applied Energy, 115: 216-225.

Ugwu, L.O, Ozuomba, J.O., Ekwo, P.I. and Ekpunobi, A.J. (2015). The Optical properties of anthocyanin – doped nanocrystalline – TiO2 and the photovoltaic efficiency on DSSC, Der Chemica Sinica. 6(11): 42-48.

Kabirad, F., Bhuiyan, M.M., Manira, M.S., Rahaman, M.S., Khan,. M.A. and Ikegamic, T.I. (2019). Development of dye-sensitized solar cell based on combination of natural dyes extracted from Malabar spinach and red spinach. Journal of Nanoscale Rest Lett.25: 198-201.

Ekanayake, A.W., Kumara, G.R.A., Rajapaksa, R.M.G. and Pallegedara, A. (2015). Increasing the Efficiency of a Dye-Sensitized Solid-State Solar Cell by Iodine Elimination Process in Hole Conductor Material.

Ozuomba, J., Ekpunobi, A. and Ekwo, P. (2011). The photovoltaic performance of dye-sensitized solar cell based on Chlorin local dye. Chalcogenide Letters, 8 (3), pp. 155-161.

Murakoshi, K., Kogure, R. and Yanagida, S. (1997). Solid state dye-sensitized $TiO_2$ solar cell with polypyrrole as hole transport layer. J Chem. Letter.5: 471-472.

Okoli, D.N., G.C. Okeke, and A.J. Ekpunobi (2010). Optical Properties of Chemical Bath Deposited Ag2S Thin Films. Pacific Journal of Science and Technology, 11(1): 411-415.

Ezenwa, I.A, and Ekpunobi, A. J. (2010).Deposition and Characterization of Cds Thin Film by Chemical Bath Method. The Pacific journal of science and Technology, USA. 11: 435-439.

Macht, B., Turrión, M., Barkschat, A., Salvador, P., Ellmer, K. and Tributsch, H. (2002). Patterns of efficiency and degradation in dye sensitization solar cells measured with imaging techniques. Solar Energy Materials and Solar Cells. Volume73: 163-173.

Andualem, A. and Demiss, S. (2018). Review on Dye-Sensitized Solar Cells (DSSCs) Edelweiss AppliSci Tech., 2: 145-150.

Brian, E.H., Eric, T.H., Paul, B.A., Jun-Ho, Y., Pascal, C., Toma´s, T., Jean, M. J., Khaja, N., Michael, G. and Michael, D.M. (2009). Increased light harvesting in dye sensitized solar cells with energy relay dyes.

Matt-Law, D. (1996). Calculation of the photocurrent-potential characteristics for regenerative sensitized semi-conductor electrodes, J. Solar Energy Materials and Solar Cells, 44, 119-155.

Lee, Y. and Kang, M. (2010). The optical properties of nanoporous structured titanium dioxide and the photovoltaic efficiency on DSSC, Mat. Chem. Phy., 122: 284-289.