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Research Article

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Preparation of solar cell using dye extracted and test for photoelectric effect from Gautan Kura (*Solanum incanum*) in Mubi L.G.A., Adamawa state Nigeria

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Abstract It gives the dye a tendency to be adhered to the porous TiO_2 semiconductor which facilitates injection of electrons to its conduction band. UV-visible analysis of the dye indicates that the chemical adsorption of this dye is generally accepted to occur because of the condensation of alcoholic-bound protons with the hydroxyl groups on the surface of nanostructured TiO_2. The dye's strong absorption in the ultraviolet region renders it.

Keywords Solar cell, photoelectric effect, Gautan Kura, *Solanum incanum*

Introduction

Dye-sensitized nanocrystalline solar cell is a nonconventional solar electric technology that gained the attention of the photovoltaic community. Its foundations are in photochemistry rather than in solid state physics, the discipline underlying today's conventional solar cells. Photovoltaic devices are based on the concept of charge separation at an interface of two materials of different conduction mechanism [1]. The dominance of photovoltaic field by inorganic solid state junction devices is now being challenged by the emergence of a third generation of cells which is based on nanocrystalline conducting polymer films [2]. This offers the prospective of very low cost fabrication and presents attractive features that facilitate market entry. It can now be possible to move away from the classical solid-state junction devices by replacing the contacting phase to the semiconductor by an electrolyte, liquid, gel or solid thereby forming a photochemical cell. A progress has recently being realized in the fabrication and characterization of nanocrystalline materials and this has opened up vast new opportunities for this systems.

The dye-sensitized nanocrystalline solar cell therefore realizes the optimal absorption and charge separation processes by association of a sensitizer as light absorbing material with a wide band gap semiconductor of nanocrystalline morphology. To date this field has been dominated by solid-state junction devices usually made of silicon, and profiting from the experience and material availability resulting from the semiconductor industry. Since the development of dye-sensitized solar cells, these have attracted considerable attention due to their environmental friendliness and low cost of production. In dye sensitized solar cells, the dye as a sensitizer plays a key role in absorbing sunlight and transforming solar energy into electric energy. Numerous metal complexes and organic dyes have been synthesized and utilized as sensitizers. By far, the highest efficiency of dye sensitized solar cells sensitized by Ruthenium containing compounds adsorbed on nanocrystalline TiO_2 reached 11–12% [3]. Although such dye sensitized solar cells have provided a relatively high efficiency, there are several disadvantages of using noble metals in them since noble metals are considered as resources that are limited in amount, hence their costly production.

Fundamentals of the Porous Nanocrystalline Solar Cell

The basis of a solar cell is a semiconductor. Its properties include enabling electron separation and transport, allowing electricity to be yielded from sunlight [4]. The semiconductor is a crystalline substance and all its atomic levels have merged to form two bands, the valence band (VB) and the conduction band (CB). The VB and the CB of the semiconductor crystal are analogues to the molecular concepts of HOMO (highest occupied molecular orbital) and LUMO (lowest unoccupied molecular orbital) [4].

Assembling the solar cell device

The photoelectrochemical solar cell was made by placing the dye coated TiO_2 plate on conducting tin oxide glass and filling the capillaries of the mesoporous film with an electrolyte containing 0.5M potassium iodide mixed with 0.05M iodine in water-free ethylene glycol [5].

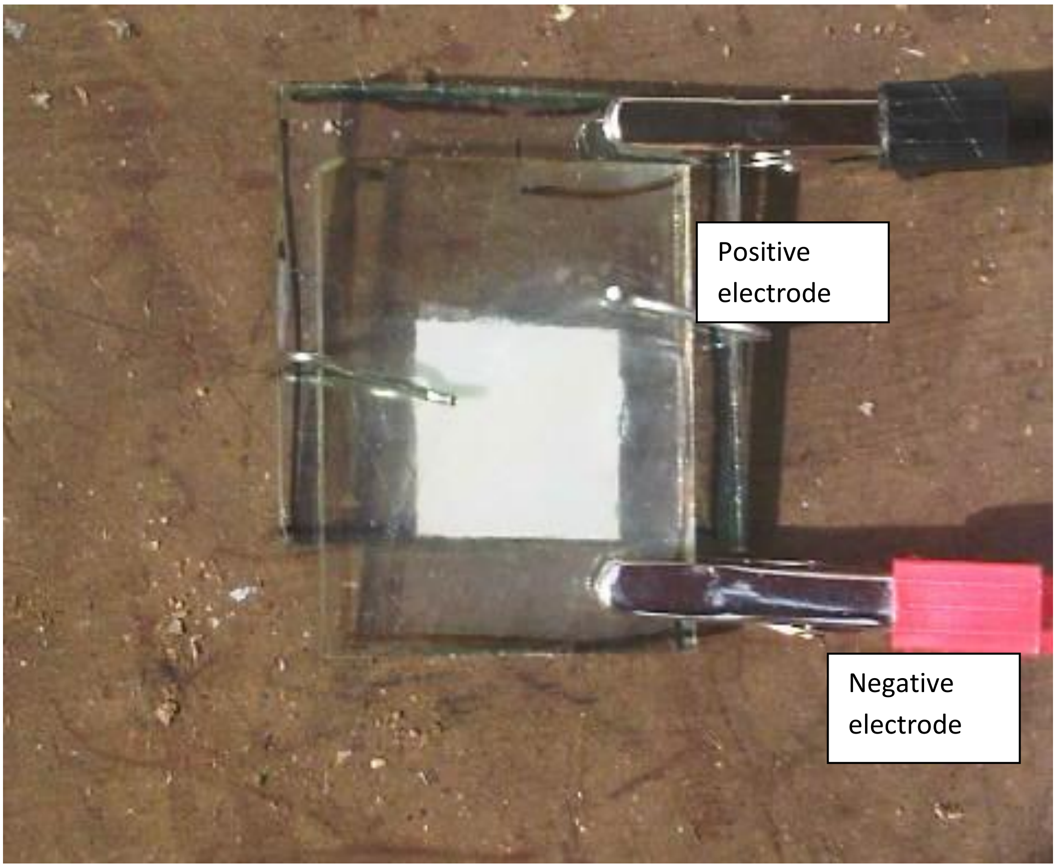

Figure 1: Typical solar cell sensitized with Solanum incanum dye connected to a volt-ohmmeter probe

Table 1: Results of the impedance analysis for DSCs using four kinds of electrodes with *Solanum incanum* natural dye as sensitizer

Electrode	Rs (Ω)	Rct (Ω)	W (Ω)	Circuit	χ^2
Pt	47.887	261.6	-	[R(C[RW])]	0.3198
Pt/Dye	47.337	524.8	6.522	[R(C[R(RQ)](RQ))]	0.0268
Pt/$Ti0_2$	48.024	2.383 E -5	-9459.2	[R(Q[R(RQ)])W]	0.0362
Pt/Dye/$Ti0_2$	60.097	-3456.6	1.5963 E +5	[R(Q[R(RQ)])W]	0.2611

Ultraviolet/visible Spectroscopy

Figure 2 shows the representative UV–visible absorption spectra of anthocyanin pigment which is a group of natural phenolic compounds for the ethanol extracts of fruits of *Solanum incanum*. The chemical adsorption of this dye is generally accepted to occur because of the condensation of alcoholic-bound protons with the hydroxyl groups on the surface of nanostructured TiO_2. The dye exhibits absorption at around 665 nm in visible region. It also strongly absorbs in the ultraviolet region with absorption peak over a range of wavelength from 305 nm to 355 nm, functionalizing as a UV filter.

Ultraviolet light falls on high band gap semiconductors generate electron and hole pairs on which the dye is adsorbed. This leads to photo degradation processes in dye sensitized solar cells and it was reported that UV filters improve the lifetime of the solar cells [6]. Therefore this pigment appears itself as a UV filter protecting the solar cell.

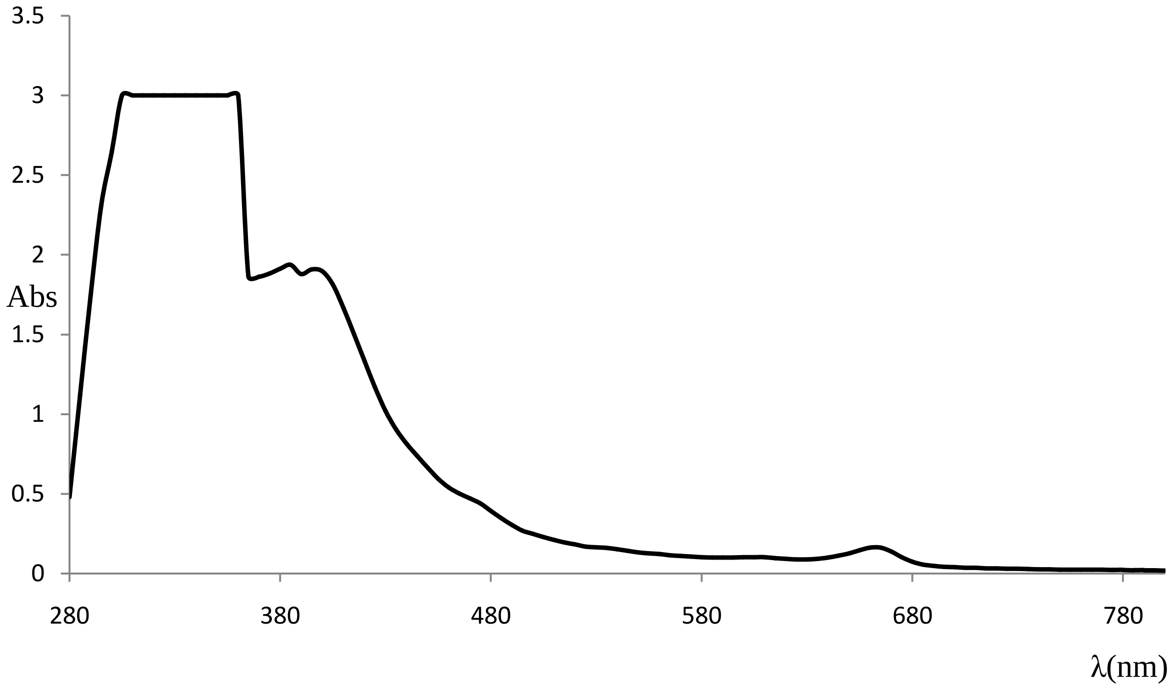

Figure 2: UV-Vis spectra of pigment extracted from the fruits of Solanum incanum plant

Fourier Transform Infrared Analysis

Fourier Transform Infrared spectroscopic measurement were carried out to identify the possible molecular functional groups responsible for the chemical behavior of the dye which enables the capture of photons of energy from the sun giving rise to emission of electrons thereby generating electricity.

The FTIR spectra (4000 - 400) cm^{-1} of the plant extract in ethanol was recorded and presented in Figure 3 and Table 2 indicates the corresponding peak areas for specific regions. The functional group identification was based on the FTIR peaks attributed to stretching and bending vibrations.

Table 2: Assignment of FTIR Spectroscopic Bands of fruits of *Solanum incanum* plant extract in ethanol

Peak No.	Band (cm^{-1})	Assignment
1	3369.50	O-H stretch, (H-bonded)
2	2946.13	C-H stretch
3	2834.98	=C-H stretch
4	1655.01	C=O stretch
5	1452.17	-C-H bending
6	1409.43	O-H bending
7	1087.28	C-O stretch
8	1028.55	C-O stretch
9	880.17	=C-H & $=CH_2$

Figure 3: is a representative FTIR Curve of *Solanum incanum*. The absorption peak no.1 is the characteristic peak of O-H stretching frequency of H-bonded alcohols and phenols [7]. It also suggests that the dye molecule

may contain a glucoside. Previous studies reports that the anthocyanin dyes with glucosides improves the photocurrent of dye sensitized solar cells [6].

The peak no. 2 indicates a C-H stretching vibration due to terminal alkenes [8]. The absorption band at no. 3 attributes to a =C-H stretching vibration which signify the presence of aldehyde-hydrogen bonded. The 4th peak is related to the stretching vibration of C=O aromatic group. The absorption peak no. 5 is a typical characteristic peak for –C-H bending vibration which can be assigned to germinal methyls. The absorption peak no. 6 is attributed to O-H bending vibrations due to the presence of alcohols and phenols. The absorption band at the 7th and 8th peaks suggests the presence of -C-O- stretching mode in ether group polyols present in flavones, terpenoids and polysaccharides [9]. The absorption band at peak number nine suggests the presence of the functional groups =C-H and $=CH_2$ from alkenes that are likely present in the dye.

The FTIR spectrum may suggest that the dye contains functional groups which help the dye to attach effectively on TiO_2 film by eliminating water molecules, and facilitate injection of electron into the conduction band of the TiO_2 thereby generating electricity.

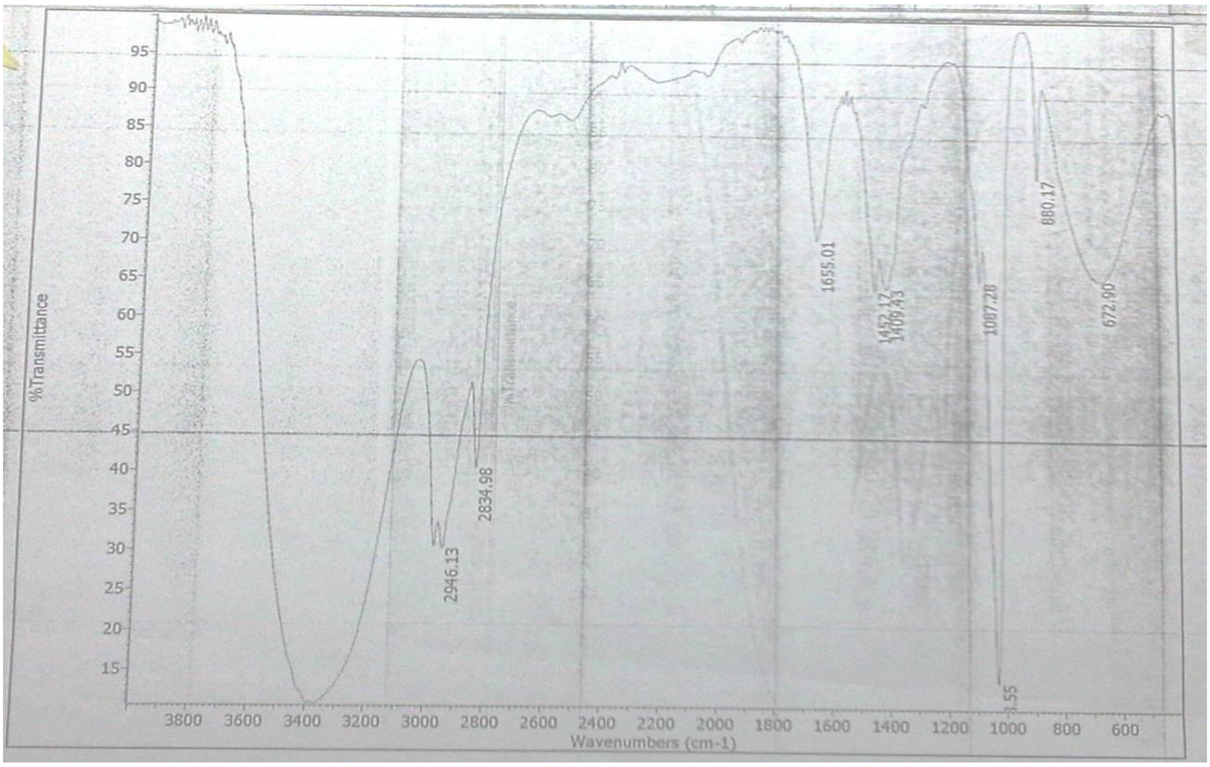

Figure 3: FTIR measurement of pigment extracted from the fruits of Solanum incanum plant

Conclusion

The natural dye extracted from the fruits of *Solanum incanum* plant shows good quality for sensitization of photoelectrochemical solar cell. FTIR analysis of the plant extract reveals functional groups of alcohols, ketones, aldehydes and carboxylic acids. It gives the dye a tendency to be adhered to the porous TiO_2 semiconductor which facilitates injection of electrons to its conduction band. UV-visible analysis of the dye indicates that the chemical adsorption of this dye is generally accepted to occur because of the condensation of alcoholic-bound protons with the hydroxyl groups on the surface of nanostructured TiO_2. The dye's strong absorption in the ultraviolet region renders it a good UV filter. The dye sensitized solar cell fabricated shows a good photoelectric effect as a maximum voltage of 0.31 V was obtained when the sun was at 11.40 am on exposure to the sun.

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