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Parametric Investigation of Solar Spectral Screening on Photovoltaic Cells using Water Solution Copper Coated *Hibiscus sabdariffa* L. Extract

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Abstract: The patronage of solar Photovoltaic (PV) panels in the tropic region is diminishing owing its under performance and low lifespan. Scientists have reported that the current harsh weather conditions are capable of destroying the solar cells of PV panels. In this research, the bio-filter was introduced to undertake spectra filtering of solar radiations hitting the surface of the PV panel. The bio-filter was made up of hibiscus extract in water solution and copper (II) nitrate tri-hydrate. The performance of the bio-filter was noticeable but very significant because of the multi-components of the hibiscus extract that have structural disadvantage to accommodate copper coating. Further research is thereby recommended to seek ways of removing the cyclopropanoids and malvalate before coating it with copper.

INTRODUCTION

A solar cell (photovoltaic cell) is a semiconductor material that converts solar energy (energy from the sun) into electrical energy. A solar panel is made up of small semiconductor units of photovoltaic cells (Emetere *et al*., 2019, 2016). A semiconductor is a material that has conductivity between a conductor and an insulator, i.e., it conducts electricity under certain conditions. These solar cells are formed by fabricating the Positive type (P) and Negative type (N) cells to produce a P-N junction (Smith *et al*., 2018). In a P type semiconductor, the major charge carriers are holes, it is formed by combining group IV and a III element, e.g., combination of silicon and boron, silicon has four valence electrons which would combine with three valence electrons provided by boron, an extra space would be left called hole. In an N type semiconductor, the major charge carriers are electrons, it is formed by combining group IV and group V elements, e.g., combination of silicon and phosphorous, silicon has four valence electrons which would combine with four electrons of phosphorous leaving the extra valence electron of phosphorous to roam free (Devasia and Kurinec, 2011; Pierret, 2003). Figure 1 shows the P-N junction.

Solar cells operate based on the principle of photoelectric effect (Nelson, 2003). Photoelectric effect is the liberation of electrons from the surface of metal when light of frequency below threshold frequency is incident on the metal (Fig. 1). The threshold frequency refers to the minimum incident light frequency that causes electrons to be released from the metal surface (Lee and Honsberg, 2013). Minimum amount of energy is called work function to start photo-electric emissions (Wurfel 2009). If the incident radiation energy quantity is less than the metal work function, no electron will be emitted. They

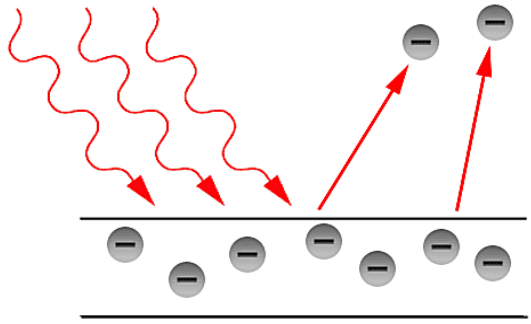

Fig. 1: Photoelectric effect principle in PV panel

are two major types of solar Photovoltaic (PV) panels, i.e., namely monocrystalline and polycrystalline (Green, 2003).The cells of monocrystalline panels are made from single crystal silicon. Some scientist believe that monocrystalline panels are more efficient than polycrystalline panels because it is made of single crystal, thereby allowing its electrons have more space to move. The polycrystalline panels are also made of silicon but instead of using single crystal silicon, manufacturers melt together many fragments of silicon to form the wafer.

Apart from the physical difference, monocrystalline panels can generate electricity even with low sunlight and there is a reduction in efficiency of the panel with high temperatures whereas polycrystalline panels barely generate electricity under low sunlight but they can function under higher temperatures than the monocrystalline (Beard *et al*., 2013). Musthafa (2015) researched on enhancing photoelectric conversion efficiency of solar panel by water-cooling. When the panel was operated under water cooling condition, the temperature dropped maximally by 40°C leading to an increase in efficiency of solar cells by 12%. Juanita (2011) carried out a research on improved solar cell efficiency through the use of an additive nanostructure-based optical downshifter. Downshifting technology is based on a nanostructured material system that absorbs high energy (short wavelength) light and reemits it at a lower energy (long wavelength) with high efficiency.

The main challenge of the use of the solar panels in tropical region is its exposure to harmful solar radiation that lowers its performance and lifespan (Lean and Rind, 1998). It is generally observed that the voltage output of any Photovoltaic (PV) panel drops by 50% within 1 year of purchase. This observation has been found to lower the patronage of PV panel in Nigeria. This research is designed to synthesize bio-filter that can filter-out the harmful spectra from the solar radiation. The research when fully perfected will increase the patronage of solar devices in the Africa market.

Fig. 2: *Hibiscus sabdariffa* L. flower

MATERIALS AND METHODS

The materials used for thus experiment includes: three 3 W monocrystalline solar panels, three 4 W polycrystalline solar panels, 2 mm connecting wires, data logger, digital multimeter, retort stand, solarimeter. The rating of the monocrystalline solar panel is: open circuit voltage (voc) = 10.8 V; short circuit current (isc) = 418 mA, maximum power voltage (vmp) = 8.2 V and maximum power current (imp) = 366 mA. The rating of the polycrystalline solar panel is: open circuit Voltage (Voc) = 22.466 V; short circuit current (Isc) = 0.235 A; maximum power Voltage (Vmp) = 18.436V and maximum power current (Imp) = 0.220 A.

The plant extract was obtained from *Hibiscus sabdariffa*. Before this experiment, it is widely known that the hibiscus extract are used for flavours, medicinal, pharmaceuticals, agrochemicals, fragrances and local dyes (Jadhav *et al*., 2009; Kalpesh *et al*., 2009; Al-Snafi, 2018).

The major component in the flower is the cyanidin 3 sophoroside. The Hibiscus sabdariffa flower (Fig. 2) was blended with waterand filtered. The filtrate collected into a beaker. The 10 mL of the filtrate was mixed with 0.0045 mole of $Cu(NO_3)_2.3H_2O$ and left a day to enable proper dissolution of copper.

The data logger can accommodate four panels in total (two monocrystalline and two polycrystalline). One monocrystalline and polycrystallinepanel was unsprayed and the other two panels (monocrystalline and polycrystalline) were sprayed. The unsprayed panels were used as control mechanism to monitor the sprayed panels. Before the panels were sprayed, it was cleaned with distilled water. The panels were afterwards put under the sun and the readings from the panels were recorded on the logger and stored in an SD card.

RESULTS AND DISCUSSION

All the panels were connected to the data logger so that the measurement are done in real time and can be compared. The solar radiation signature for monocrystalline and poly crystalline panel is presented in Fig. 3a and b respectively. Both solar panels recorded same solar pattern. Generally, it is observed that the transient state of the solar radiation is characterized by high fluctuations. This result corroborates the fact that the tropic experience harsh solar radiation that are capable of destroying PV panel.

The current generation in both the monocrystalline and polycrystalline panels are shown in Fig. 4a and b respectively. It was observed that the current of the sprayed panel is lower than that of the unsprayed panel for the monocrystalline panel. In the polycrystalline panel, the current of the unsprayed panel is lower than that of the sprayed panel. However, in the later part of the current production, the current of the sprayed panel is lower than that of the unsprayed panel.

The voltage generation in both the monocrystalline and polycrystalline panels are shown in Fig. 4a and b respectively. It was observed that voltage of the unsprayed panel was higher than voltage of the sprayed panel in the monocrystalline panel. However, it was the opposite for the polycrystalline, i.e., the unsprayed panel was lower than voltage of the sprayed panel.

It is observed that the efficiency of the bio-filter to stabilize the reading on the panels was not very significant. This may be adduced to the multi-component of the hibiscus flower, i.e., cyclopropanoids, methyl sterculate, methyl-2-hydroxy sterculate, 2 hydroxy sterculate, malvalate and beta-sitosterol. The incorporation of the copper coating might have been mitigated by one of the minor hibiscus component. For

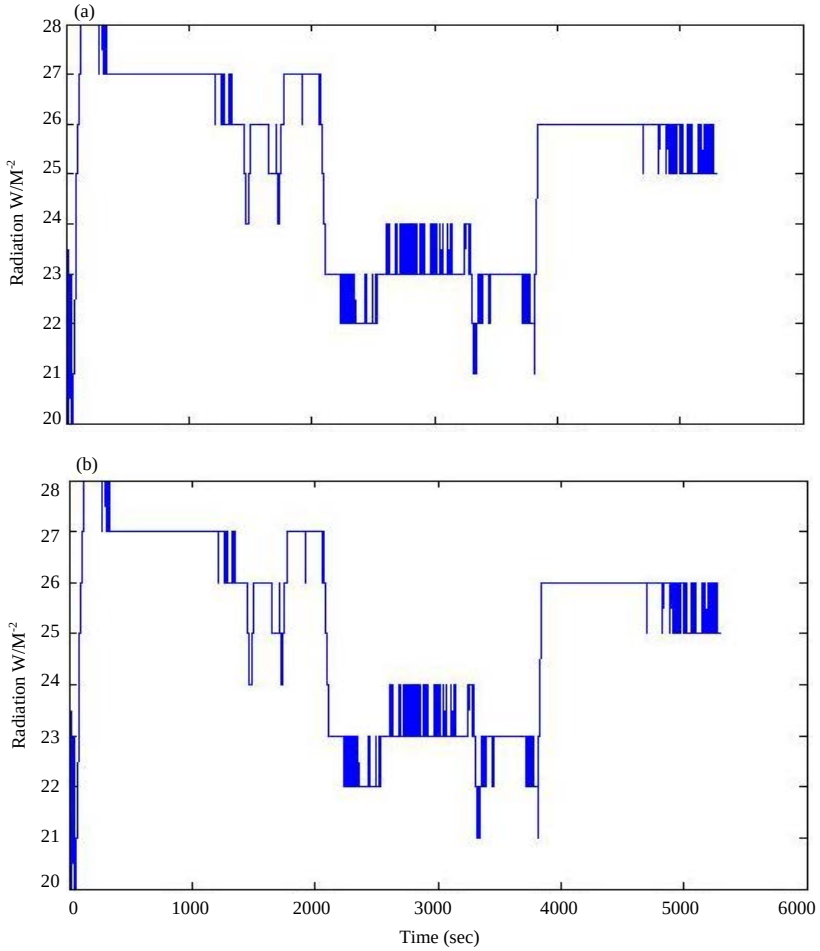

Fig. 3(a, b): Solar radiation signature for (a) Monocrystalline panel and (b) Polycrystalline panel

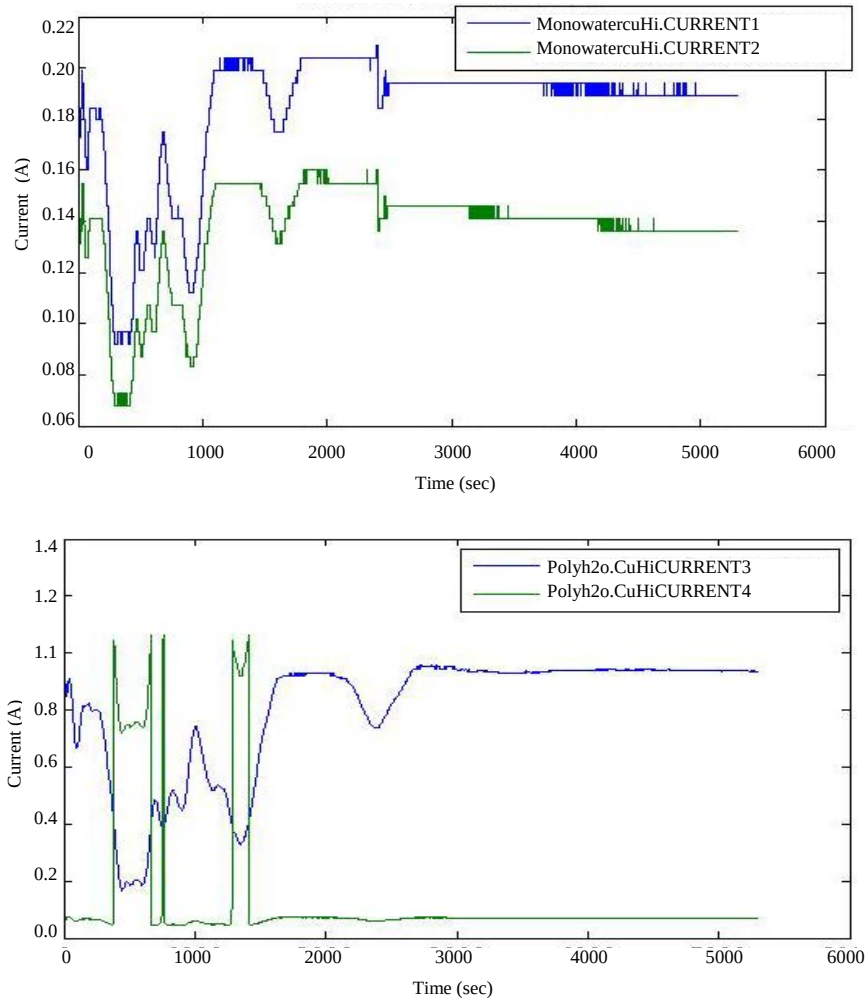

Fig. 4(a, b): Current production for, (a) Monocrystalline panel and (b) Polycrystalline panel

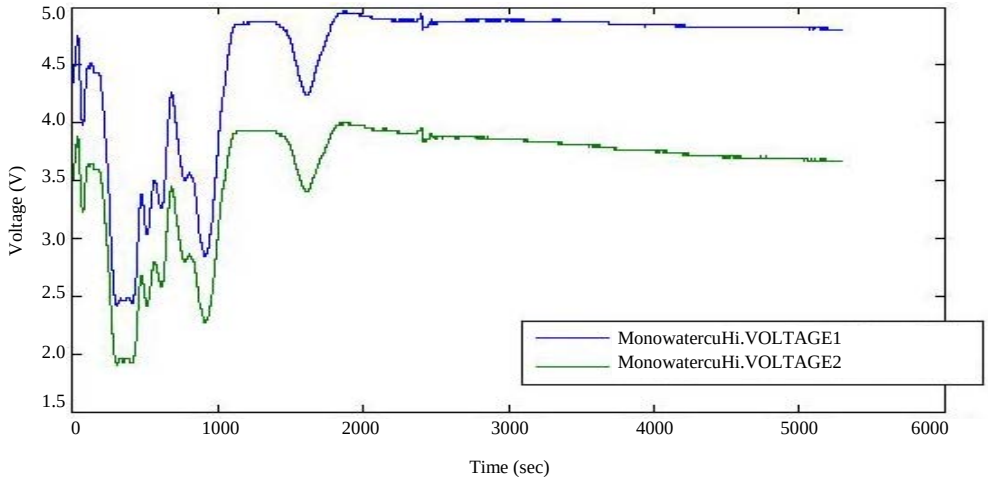

Fig. 5: Hibiscus water copper extract for monocrystalline panel

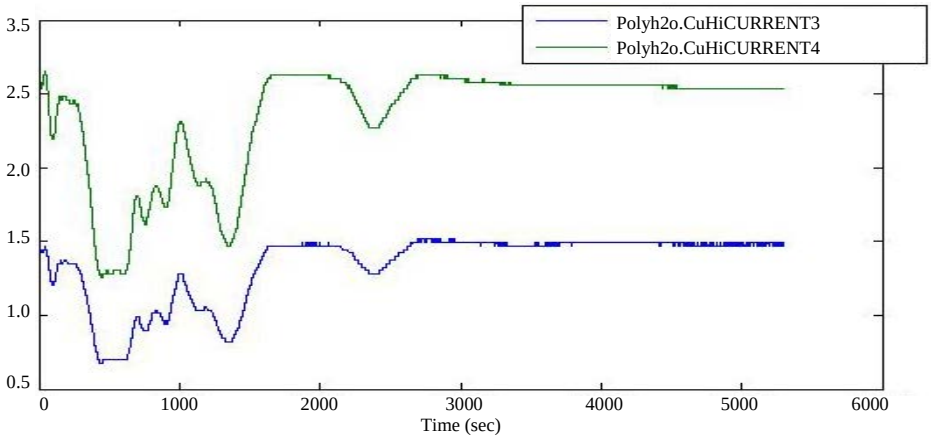

Fig. 6(a, b): Voltage production for (a) Monocrystalline panel and (b) Polycrystalline panel

further research, it is recommended that the cyclopropanoids and malvalate be removed from the extract before coating it with copper Fig. 5 and 6.

CONCLUSION

The hibiscus extract was proposed as one of the component of an envisaged bio-filter that is capable of filtering solar spectra during harsh weather condition. It was generally observed that the bio-filter was successful to an extent. It was observed that the inefficiency of the bio-filter was traceable to their multi-components that have structural disadvantage foraccommodating the copper coating. Further research is thereby recommended to seek ways of removing the cyclopropanoids and malvalate before coating it with copper.

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