Spectral filtering of photovoltaic cells using novel bio-filter: Silver coated Hibiscus extract using methanol solution

Emetere M.E.\textsuperscript{1,\textdagger}, and Adeyemo Nehemiah\textsuperscript{1}

\textsuperscript{1}Department of Physics, Covenant University, Ota, Nigeria.
\textsuperscript{2}Department of Mechanical Engineering & Science, Univ. of Johannesburg, APK, South Africa
emetere@yahoo.com

Abstract. Spectra filtering is a fairly new concept to control the damaging contributions of solar IR radiations to photovoltaic (PV) cells or panel. In this research, the bio-filter was synthesized and tested. The bio-filter was proposed as the panacea to filtering the solar IR radiations. The bio-filter performance was adjudged to show little success, as it was 3\% lower than the normal performance in the monocrystalline solar PV panel and 50\% higher than the normal performance in the polycrystalline solar PV panel. The varying results in the polycrystalline and monocrystalline PV panels may arise as a result of unequal coating of the panel. Hence, the coating technique is recommended to be uniform and precise in further research work.

1. Introduction

It has been reported that solar infrared spectrum is dangerous to photovoltaic panel because it destroys PV cells and reduce its lifespan [1-3]. The infrared spectrum refers to the invisible part of the electromagnetic spectrum with short frequency than those of visible light but less than that of microwaves, wavelengths of infrared ranges from about 700nm to 1mm [4-5]. Hence the energy of infrared is less than that of visible light. This wave spectrum is commonly associated with heat radiated by bodies. On the other hand, the visible spectrum is unique because it is the segment of the electromagnetic spectrum that the human eye can view. Furthermore, this range of wavelengths is called visible light. Surprisingly, the human eye can detect wavelengths from 380 to 700 nm. Violet is the shortest wavelength of the visible spectrum (at around 380 nm) and red has the longest wavelength, at around 700 nm [6]. Of the light that reaches Earth’s surface, infrared radiation makes up 49.4\% of while visible light provides 42.3\% [7]. Scientists have been working hard on the PV technology to solve this challenge [8-10]. In this research, we present the concept of bio-filter that can be sprayed on the PV panel to filter the solar IR radiations. This bio-filter is not responsible to make solar irradiance uniform on the PV panel, in the contrary; it tries to normalize seemingly fluctuations. The research seeks to screen plant extract to elongate the life span or improve the efficiency of solar cells by investigating the different wavelength of light incident on the PV panel and how they affect the cell, thereby devising a means to filter out different spectral using silver coated plant extract which will reflect heat from the cells and allow light to pass through it [11-12]. This experiment would improve on the spectra selection incident on the solar PV cell, thereby aiding maximum performance of solar panels [13-14].

The plant extract used for this study is the hibiscus flower. Hibiscus is a genus of flowering plants that belongs to the Malvaceae family [15]. Hibiscus has over three hundred species and it is believed to have salient chemical properties to trap solar IR radiation. The bio-filter is expected to optimize and stabilize the performance of the PV panel. The polycrystalline and monocry stalline PV panels are used to test the efficiency of the synthesized bio-filter.

2. Experimental Design, Materials and Methods

The materials used for the experiment includes: monocry stalline panel (3watt), solarimeter, silver nitrate (Ag\textsubscript{2}NO\textsubscript{3}), polycrystalline panel (4 watt), methanol solution, multimeter, weighing balance, beaker and data logger.
The bio-filter was synthesized in the laboratory using hibiscus flower extract and silver nitrate. The hibiscus flower were gotten around the Ota environ, Nigeria. The flowers were divided into four parts. Each portion of the flower was grinded (using electronic blender) in 20ml of methanol. After blending, extracts were filtered out and mixed with 1.84g/mole of silver oxide (Ag₂NO₃) and then left for a day so that the silver compound can dissolve with the mixture. The filtrate was not heated to conserve the vital chemical components of the hibiscus flower (saturated hydrocarbons from 25 to 33 carbon atoms, esters, and carboxylic acids [15]). The two-polycrystalline PV panels (i.e. one panel sprayed with the bio-filter and the second panel not sprayed) and four monocrystalline panels (i.e. two sprayed with the bio-filter and the other two panels not sprayed) were connected to the data logger as shown in Figure 2.

![Figure 1: Bio-filter composition](image1)

The data logger was used to measure desired parameters such as radiation, current, voltage and power for two types of PV panels i.e. monocrystalline and polycrystalline [16]. A data logger records and saves all readings gotten from the PV panels in an SD card.

![Figure 2: Experimental set-up for field measurement](image2)

3. Results and Discussion
The graph below (Figure 3) shows the UV radiation (w/m²) against time (sec) plot of the silver coated hibiscus extract in methanol solution for the polycrystalline panel. The UV over the period showed peaks at 700 sec and 4600 sec indicating high UV radiation.

![Figure 3: UV radiation (w/m²) against time (sec) of silver coated hibiscus extract in methanol solution for the polycrystalline panel](image)

The graph below (Figure 4) shows the voltage (V) against time (sec) plot of the silver coated hibiscus extract in methanol solution for the polycrystalline panel. The blue legend shows the coated panel while the green legend shows the uncoated polycrystalline panel. It is observed from that the coated panel produced a higher voltage relative to time than the uncoated panel. It is also noticed that there was a steady rise and fall in the voltage as time increased.

![Figure 4: Voltage (V) against Time (Sec) of the Silver coated hibiscus extract in methanol solution for the polycrystalline panel.](image)

The graph below (Figure 5) shows the current (A) against time (sec) plot of the silver coated hibiscus extract in methanol solution for the polycrystalline panel. The blue legend shows the coated panel while the green legend shows the uncoated polycrystalline panel. It is observed from that graph that the coated panel produced a higher current relative to time than the uncoated panel. It is also noticed that (like the voltage trend) there was a steady rise and fall in the current as time increased.
Figure 5: Current (A) against Time (Sec) of the Silver coated hibiscus extract in methanol solution for the polycrystalline panel.

The graph below (Figure 6) shows the power (W) against time (sec) plot of the silver coated hibiscus extract in methanol solution for the polycrystalline panel. The blue legend shows the coated panel while the green legend shows the uncoated polycrystalline panel. It is observed from that the coated panel produced a higher power output relative to time than the uncoated panel. It was also noticed that there was a steady rise and fall in the power. Hence, in Figures 4-6, the bio-filter improved the performance of the polycrystalline panel by 50%.

Figure 6: Power (W) against Time (Sec) of the Silver coated hibiscus extract in methanol solution for the polycrystalline panel.

The graph below (Figure 7) shows the UV radiation (w/m²) against time (sec) plot of the silver coated hibiscus extract in methanol solution for the monocrystalline panel. The UV was very low because it was a cloudy day.
Figure 7: UV radiation (w/m$^2$) against Time (sec) of Silver coated hibiscus extract in methanol solution for the monocrystalline panel.

The graph below (Figure 8) shows the voltage (V) against time (sec) plot of the silver coated hibiscus extract in methanol solution for the monocrystalline panel. The blue legend shows the coated panel while the green legend shows the uncoated monocrystalline panel. It is observed from the graph that the uncoated panel produced a high voltage output with respect to time than the coated panel.

Figure 8: Voltage (V) against Time (Sec) of the Silver coated hibiscus extract in methanol solution for the monocrystalline panel.

The graph below (Figure 9) shows the current (A) against time (sec) plot of the silver coated hibiscus extract in methanol solution for the monocrystalline panel. The blue legend shows the coated panel while the green legend shows the uncoated panel for the monocrystalline panel. It is observed from the graph that the uncoated panel produced a high current output with respect to time than the coated panel.
Figure 9: Current (A) against Time (Sec) of the Silver coated hibiscus extract in methanol solution for the monocrystalline panel.

The graph below (Figure 10) shows the power (W) against time (sec) plot of the silver coated hibiscus extract in methanol solution for the monocrystalline panel. The blue legend shows the coated panel while the green legend shows the uncoated panel for the monocrystalline panel. It is observed from the graph that the uncoated panel produced a high-power output with respect to time than the coated panel. Hence, in Figures 8–10, the effect of the bio-filter on the monocrystalline panel was as low as 8%. It was because there was not uniform coating of the monocrystalline panel.

Figure 10: Power (W) against Time (Sec) of the Silver coated hibiscus extract in methanol solution for the monocrystalline panel.

4. Conclusion

The bio-filter performance was adjudged to show little success, as it was 3% lower than the normal performance in the monocrystalline solar PV panel and 50% higher than the normal performance in the polycrystalline solar PV panel. This experimentation supports bio-filter as an external material that will optimize and stabilize the performance of the PV panel. The varying results in the polycrystalline and monocrystalline PV panels may arise as a result of unequal coating of the panel. Hence, the coating technique is recommended to be uniform and precise in further research work.

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