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# Novel Liquid Semiconductor Shield for Photovoltaic Modules: Application at Liquid State

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**Abstract.** Inefficiency of the polymeric material of the photovoltaic (PV) module to shield the solar cell from UV radiation has made the maintenance cost of solar energy generation high. The results from the usage of colour plastic cellophanes as PV shield are not promising. In this study, a novel solid-state bio-filter (SSB) was synthesized using silver nitrate salt and hibiscus flower extract. The results show that the novel SSB material mitigates UV radiation via two processes i.e. reflection of UV radiation and processing of the remaining UV radiation into peaks. It was also observed that the SSB has three absorption levels and a bandgap of 3.194 eV. It is recommended that further study be carried-out to estimate the portion of UV radiation that has been reflected.

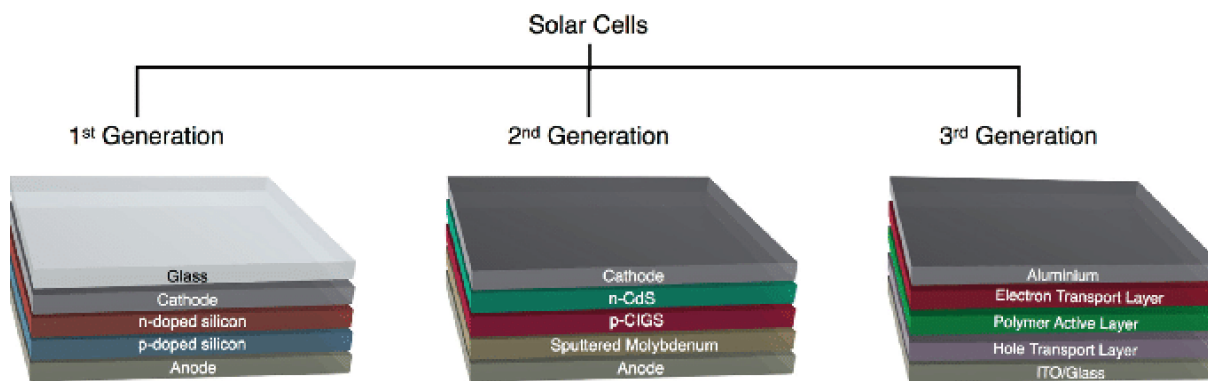
## 1. Introduction

The need for energy increased as technology evolved. From the basic need of energy for cooking, technology has created different options of comfort that requires more energy to access. The rising energy need has necessitated the enactment of policies that has increased energy generation. Energy generation has also evolved as more efficient ways of generating energy from a single process are discovered. The hydropower plant, coal power plant and nuclear power plant are typical example of a single source energy generating process that can generate huge energy [1-3]. Almost all countries in the world have adopted hydropower plant, coal power plant or nuclear power plant. Despite the large energy that can be generated from the hydropower plant or nuclear power plant, most parts of the globe cannot be reached due to cost and planning. The fossil-fuel generator became a good substitute for domestic and industrial use. A public report claimed that the amount spent by populace in some developing countries on fossil fuel generator is above the health or education budget of the nation [4-5]. The fossil fuel generator (FFG) has gained huge momentum in the global market with sizeable population employed directly or indirectly.

Some of the sources of energy became source of concern as it was evident that its waste (emission of greenhouse gases, radioactive waste, release of wastewater) has adverse effect on the environment [6-8]. Notable evidence of the adverse effect of unclean sources of energy include global climate change, air pollution, water pollution, outbreak of strange diseases, high maternal and infant death rate, and land pollution. The clamour for clean energy is has taken the centre stage in the world. Top on the list of clean energy is solar energy whose source is the sun. The sun is a renewable source and cannot be exhausted. The energy accruable from the sun was estimated to be 384.6 yotta watts [9]. The investments on solar devices are huge with a growing global market. Most developed countries have already integrated its solar energy generation into the grid system. Aside, nations investing in solar devices, the numbers of standalone users have greatly increased. Most prominent of the solar

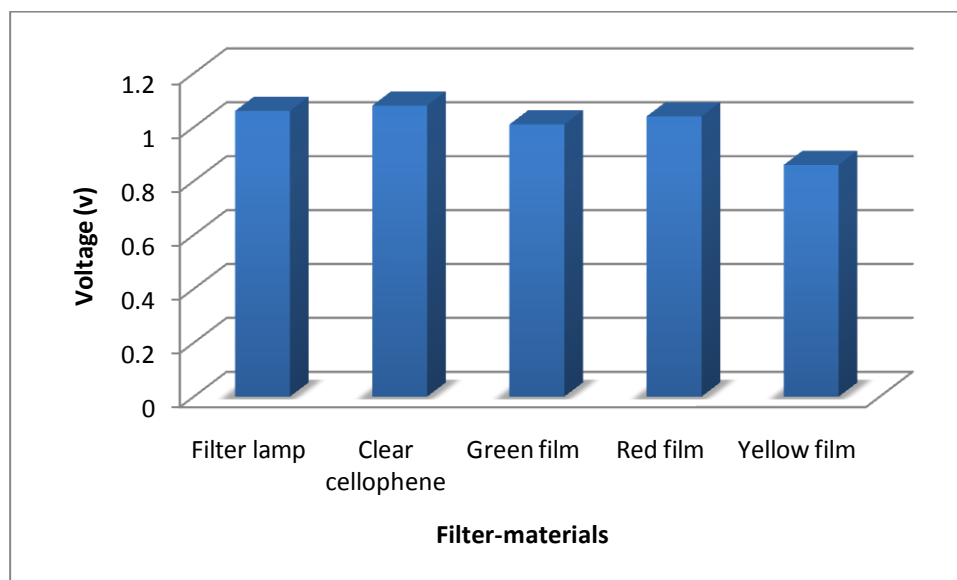


device in the market is the thermovoltaic and photovoltaic. The photovoltaic has gained more patronage or usage because of its cost, availability and scalability. The photovoltaic technology has evolved i.e., from first, second and third generation photovoltaic. The layers of a typical photovoltaic are presented in Figure 1. Aside the different layers of the solar cells and materials of each photovoltaic generation, the similarity in all is that it has polymeric layer that encapsulate the solar cell. This type of layer is designed to protect the solar cells from mechanical stress and environmental conditions.



**Figure 1.** Layers of different generation of photovoltaic

It has been discovered that the polymeric materials cannot shield the PV module from UV radiation that damages the solar cells. This discovery is disturbing for tropical regions because they have higher UV radiations. The lifespan of PV modules that originally should be 15 years are reduced to two years at low efficiencies. The shielding of the PV module using coloured plastic cellophanes have shown several disturbing results shown in Figure 2. Also, there is the UV filter stack that have yielded low results [10].



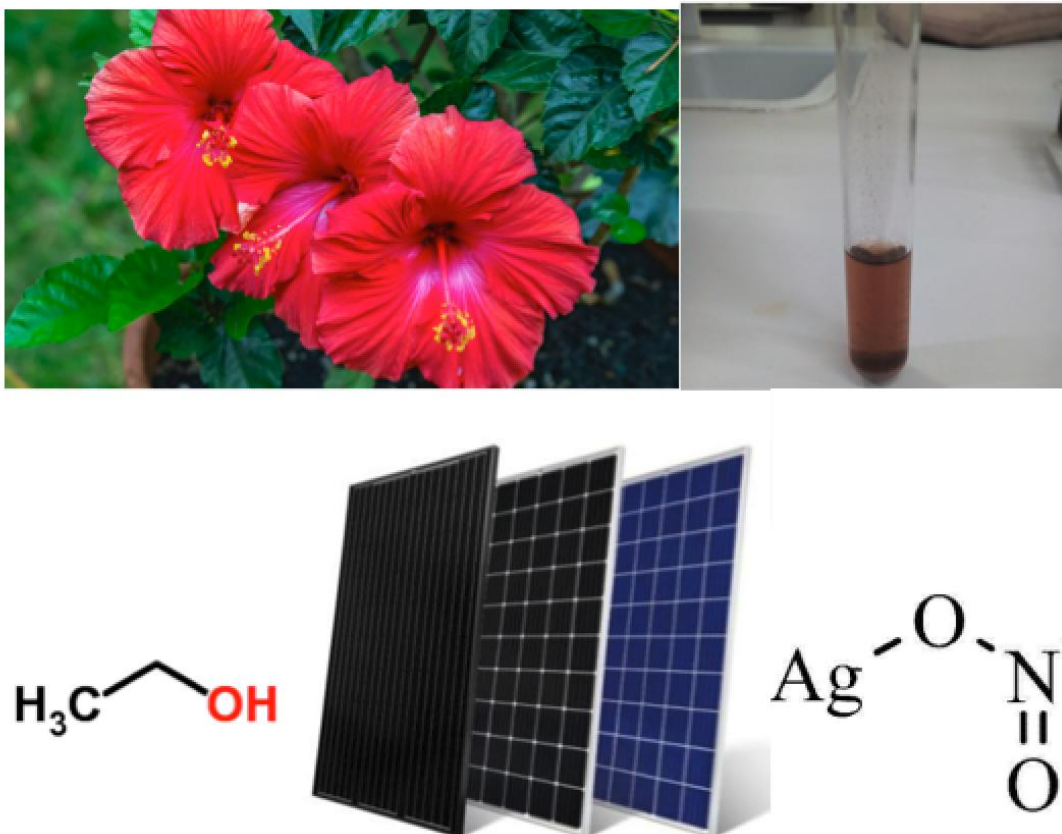
**Figure 2.** Results of different plastic filters [11]

The option of the solid state bio-filter (SSB) as a supportive layer to the polymeric material was first suggested in literatures [12-15]. This method requires the use of a metallic coated plant extract that works as a liquid semiconductor. Experiments have shown that SSB reflects some portion of the UV radiation and process the remaining portion as a semiconducting material, thereby improving the

quality of solar irradiance reaching the solar cells. The target of this paper is not the energy generation in the PV module, but how effective the SSB can protect the PV module. The focus of the study is to fabricate a solid state biofilter.

## 2. Methodology

The hibiscus flower has basic chemical components such as tannins, anthraquinones, quinines, phenols, flavanoides, alkaloids, terpenoids, saponins, cardiac glycosides, protein, free amino acids, carbohydrates, reducing sugars, mucilage, essential oils and steroids [16]. The materials used for the experiments include hibiscus flower, ethanol, monocrystalline module, connecting wires, voltage sensor, current sensor, arduino, silver nitrate salt, clips and mechanical spray.



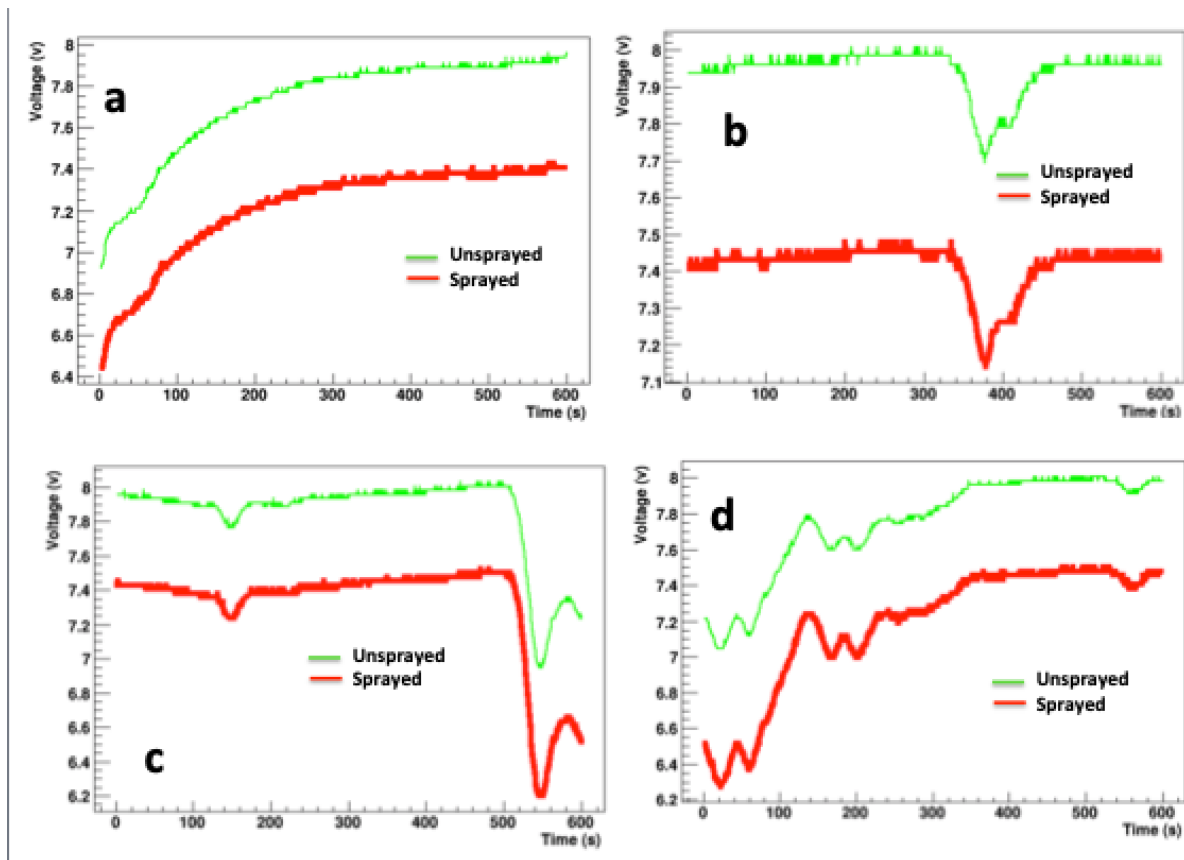
**Figure 3.** Basic materials for the experiments

The hibiscus flower was extracted using the ethanol solution as described in ref [14-15]. The extract was then doped with 0.01 mole of silver nitrate salt. The mixture was stirred under room temperature to give a homogenous compound as shown in Figure 3. The mechanical spray was used to spral 0.3ml of the extract on the monocrystalline module. Two modules were used for the experiment. The unsprayed module was used as the control to monitor the progression of the SSB. The dataset was logged-in automatically into an SD card that was attached to an arduino set-up. Mathematical formulae was used to estimate the absorbance and band gap of the SSB at its liquid state.

## 3. Results and Discussion

The voltage dataset of the sprayed and unsprayed PV module is presented in Figure 4. The SSB was measured at the liquid state. It was observed that the SSB had higher voltage. The SSB as a solid state device converts the solar irradiance signal to peaks not curve as presented in the unsprayed PV module. The SSB at liquid state first acts a reflector. It reflects some of the UV radiation and process the remaining portion of the PV module. The SSB is not expected to stabilize the solar irradiance on the

PV module, that is the reason both the sprayed and unsprayed PV module have same trend as presented in Figure 4. The SSB process the received solar irradiance signal and converts it in form of peaks not in curves (as seen in the unsprayed PV module). The processed signal is absorbed by other layers of the monocrystalline PV module to yield high voltage. From the voltages, it can be inferred that the SSB can mitigate UV radiation by 14% in the processed form. The percentage of UV radiation that reflected by the SSB was not reported in this paper. This is recommended for future study. The absorbance of the SSB is presented in Figure 5. The estimation of the SSB absorbance was done by using the differential in the voltages of the sprayed and unsprayed PV modules and applying the equation 1. Despite the solar irradiance pattern seen on the voltage outcome, it was observed that the SSB absorbance had three basic absorption levels that controls it. The band gap of the SSB was calculated based on its absorbance in Figure 6.



**Figure 4.** Voltage characteristics of the SSB on PV module

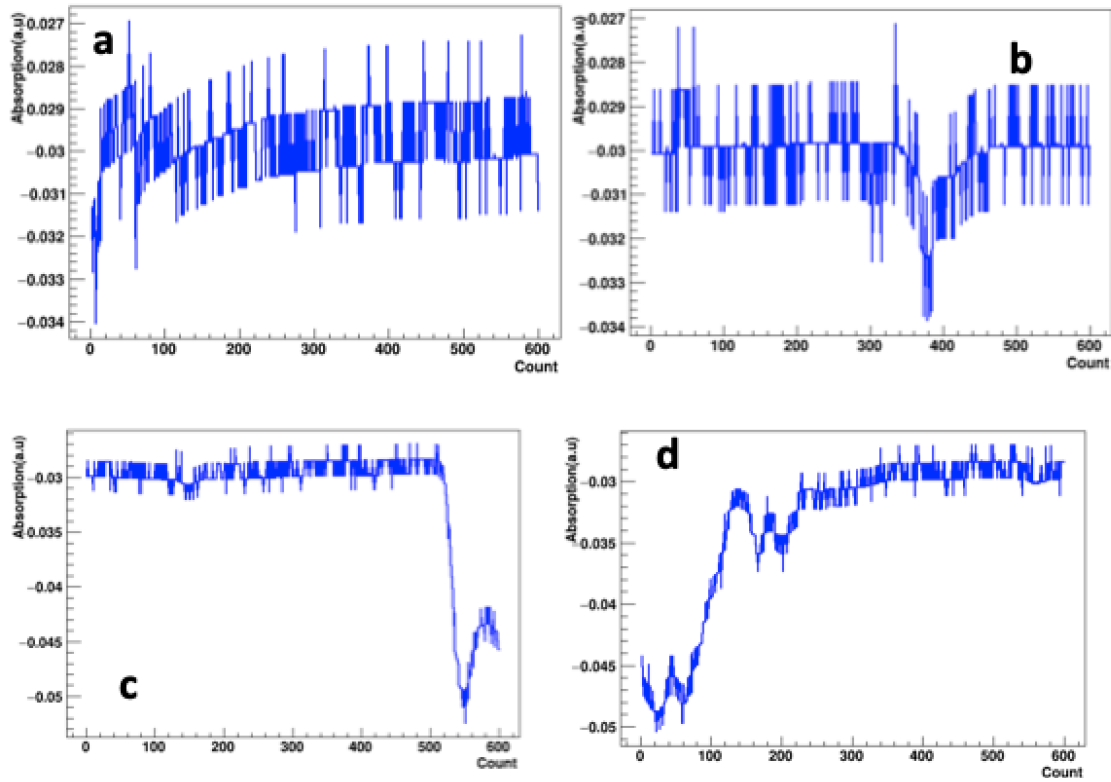


Figure 5. The absorbance of SSB

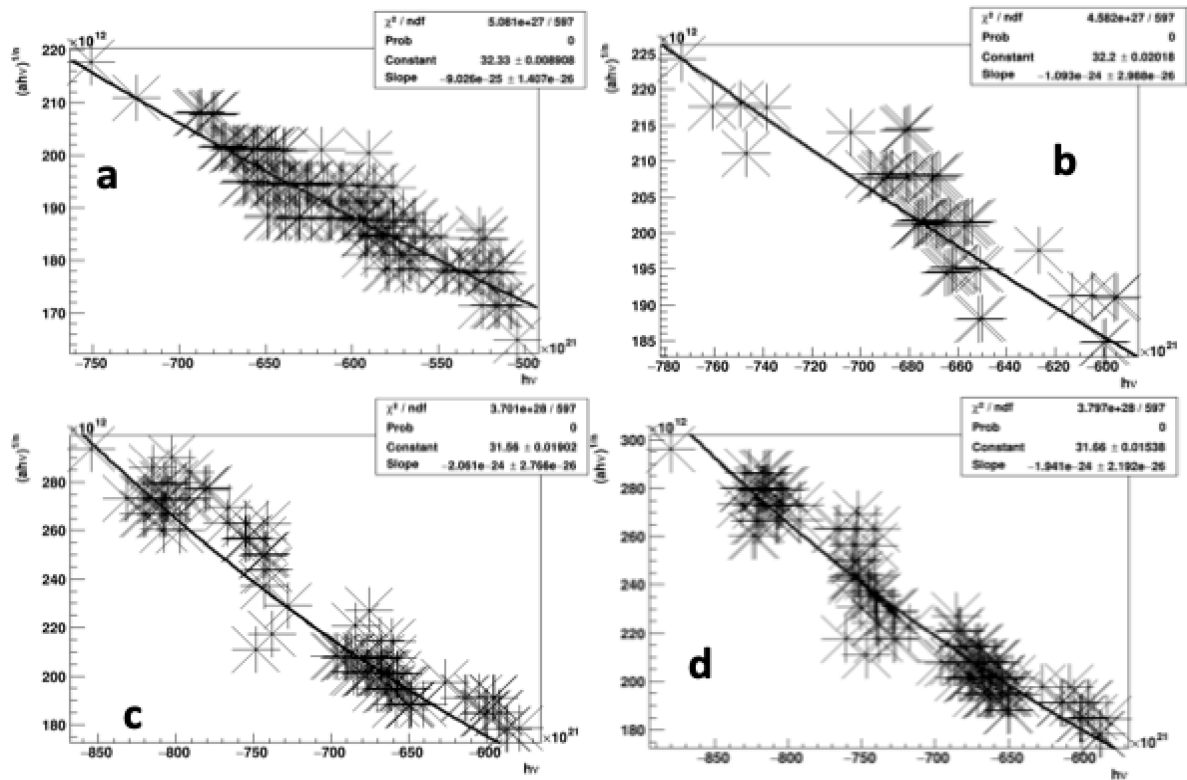


Figure 6. Band gap estimation of SSB



$$A = -\log \frac{I}{I_0} = -\log \left( \frac{V_{\text{sample}} - V_{\text{zero}}}{V_{\text{solvent}} - V_{\text{zero}}} \right) \quad (1)$$

Where A is the absorption,  $V_{\text{sample}}$  is the voltage on the clean PV module;  $V_{\text{solvent}}$  is the voltage of the sprayed PV module.  $V_{\text{zero}}$  is the differential voltages between the sprayed and unsprayed PV module. From Figure 6, the band can be obtained using

$$y = mx + C \quad (2)$$

where  $y = (ahv)^{1/n}$ ,  $x = hv$ , m is the slope and C is the constant or intercept. The band gap is calculated via the intercept as

$$\text{BG} = \frac{C}{n} \quad (3)$$

where n is the dilution factor given as 10. Hence, the band gap of the SSB at liquid state for the four measurements is given as 3.233 eV, 3.22 eV, 3.156 eV and 3.166 eV. This means that at liquid state, the SSB has a band gap of 3.194 eV. This means this SSB is in the range of gallium nitride [17].

#### 4. Conclusion

The study has examined the effect of the liquid state of novel SSB. The SSB has shown that it has the potential to improve the efficiency of the monocrystalline PV module by 14%. The SSB has three main absorption level that enable the excitation of electrons when it receives solar irradiance signals. This optical properties were enabled the liquid state SSB to reflect UV radiation and process the remaining signals in form of peaks. The PV module to yield higher voltage output reabsorbs these peaks. However, the shortcoming of this work is not been able to determine the percentage of UV radiation that can be reflected by the SSB. Hence, it is recommended for further study the estimation of the reflective properties of the novel SSB material.

#### 5. Acknowledgments

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