STUDY OF AN INSTALLATION OF ORGANIC PHOTOVOLTAIC (OPV) DEVICES IN URBAN EQUIPMENT

[1] SANTOS, Talitha R. C. dos, Department of Physics, University Federal of Paraná, Brazil.
E-mail (talitha.ramos@ufpr.br)
[2] TEMPESTA, Anna G., Department of Physics, University Federal of Paraná, Brazil.
E-mail (anna.tempesta@ufpr.br)
[3] MARIANO, Luiz C., Department of Physics, University Federal of Paraná, Brazil.
E-mail (luizcarlos.mariano@ufpr.br)
[3] ROMAN, Lucimara S., Department of Physics, University Federal of Paraná, Brazil.
E-mail (lucimara.roman@ufpr.br)

INTRODUCTION

With the growth of the world population and economic development, the demand for energy increases every year. Currently, most of the energy we consume comes from non-renewable sources, raising concerns about environmental impacts. Among the many clean and renewable energy sources available, solar energy is the most abundant and possesses several potential applications (Energy International Administration - EIA, 2019). In countries with high incidence of sunlight during the year, such as Brazil, the use of photovoltaic panels is already a reality, but it still needs more research and market investments.

Organic photovoltaic (OPV) panels were developed as an alternative for other types of applications that are not possible with crystalline inorganic panels (Inganas, 2018). OPV panels can be flexible and semi-transparent, and these characteristics allow them to be employed on different urban constructions, such as curved structures and windows.

Bus Rapid Transit (BRT) is the main public transport system in Curitiba, a city in southern Brazil. Curitiba's BRT stations have been considered a symbol of the city since the 1990s (Leitman and Rabinovich, 1996). These stations have a cylindrical shape and are popularly known as tubelike bus stations. The panels studied in this work were installed on the side of a tube station, one inside and one outside—called internal OPV and external OPV, respectively—on a curved glass structure as shown in Figure 1. The placement was chosen in order to diversify the application of OPV panels in tube stations, since a previous work placed them in the upper external part of the tube station (Tempesta et al., 2019).

Figure 1: View from outside of the tubelike bus station used in this work (left) and the view from inside, with the installed panels (right).

In this work, the performance of commercial OPVs that use non-fullerenes as their active layer will be analyzed. The OPVs used were produced by Sunew/Csem Brazil and acquired through a research and development project from COPEL (Paraná Electricity Company) (grant 2866-0470/2017). All the panels used in this research were produced using the roll-to-roll technique and have the same active layer. However, due to industrial secrecy, there is no information on which polymer constitutes it.

MATERIALS AND METHODS

To investigate the performance variation of OPV panels, outdoors tests were conducted in an installation located in an urban environment. The external OPV panel is 1776 cm² and the internal OPV is 3024 cm² with an active layer. We attempted to replicate the tests according to ISOS O-2 standards for testing under light (Reese et al., 2011). However, access to the locations where the panels are installed and obtaining their data is restricted to the climatic conditions of Curitiba.

Outdoor tests were conducted from January to March 2020. To evaluate the panels, J x V curves were plotted using a precision source to supply voltage and measure the electric current. A 3-hour interval between 11 am and 3 pm, with a higher incidence of direct sunlight on the panels, was chosen to perform the measurements under light.

RESULTS AND DISCUSSION

The outdoor tests under light were conducted from January to March 2020, favoring days with clear skies or few clouds: January 27; March 4, 12 and 19. The J x V curves obtained from the internal OPV are shown in Figure 2. The calculated photovoltaic parameters and data for the internal measurement days are shown in Table 1.

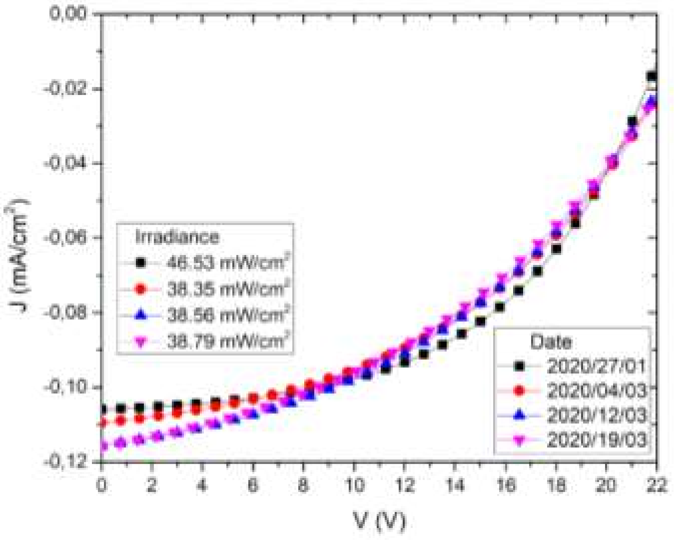

Figure 2: Characteristic J x V curves of the internal OPV for outdoor tests under light.

The J x V curves under illumination obtained with the measurements on the external OPV are shown in Figure 3. The calculated photovoltaic parameters and data for the external measurement days are shown in Table 2. By analyzing the graphs and data obtained, we noticed that the internal OPV presented a more efficient response, in comparison with the external OPV.

Table 1: Photovoltaic parameters obtained from the characteristic curves of the internal OPV on the days that the outdoor tests were conducted.

Date (2020 y)	V_{oc} (V)	J_{sc} (mA/cm²)	R_{sh} (ohm)	R_s (ohm)	FF (%)	PCE (%)	Irrad (mW/cm²)
27/01	22.65	1.06×10^{-1}	3.67×10^{6}	4.89×10^{4}	51.61	2.66	46.53
04/03	23.59	1.10×10^{-1}	1.45×10^{6}	6.68×10^{4}	44.92	3.03	38.35
12/03	23.62	1.16×10^{-1}	1.03×10^{6}	7.12×10^{4}	42.48	3.01	38.56
19/03	23.81	1.16×10^{-1}	8.70×10^{5}	7.74×10^{4}	40.92	2.91	38.79

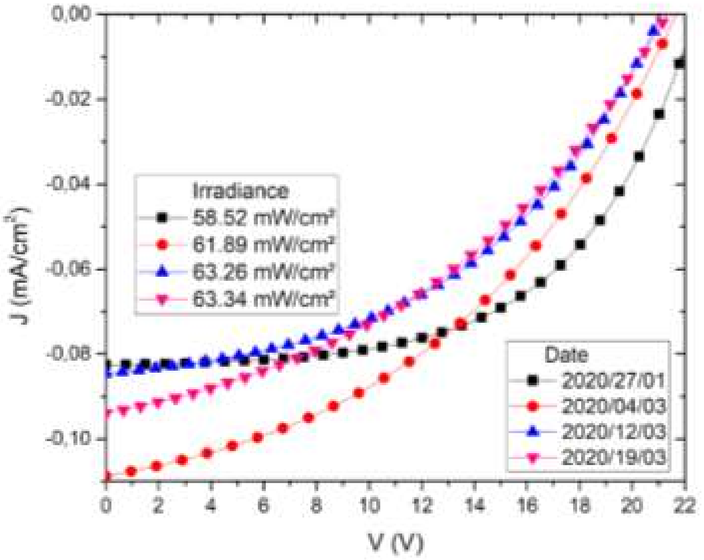

Figure 3: Characteristic J x V curves of the external OPV for outdoor tests under light.

Table 2: Photovoltaic parameters obtained from the characteristic curves of the external OPV on the days that the outdoor tests were conducted.

Date (2020 y)	V_{oc} (V)	J_{sc} (mA/cm²)	R_{sh} (ohm)	R_s (ohm)	FF (%)	PCE (%)	Irrad (mW/cm²)
27/01	22.40	8.26×10^{-2}	1.14×10^{7}	4.97×10^{4}	56.56	1.78	58.52
04/03	21.66	1.09×10^{-1}	8.99×10^{5}	7.27×10^{4}	41.51	1.58	61.89
12/03	21.11	8.46×10^{-2}	1.80×10^{6}	7.53×10^{4}	45.51	1.28	63.26
19/03	21.32	9.40×10^{-2}	8.33×10^{5}	9.14×10^{4}	39.58	1.25	63.34

A possible explanation for this efficiency in the response of the internal OPV is the presence of a glass layer between the panel and the external environment. This glass has a film that prevents part of the solar radiation from reaching the internal environment of the tube station.

Thus, one hypothesis for the better internal response of the OPV under light is that the glass layer is partially absorbing the radiation inefficient in generating charges, while the panel receives more concentrated light energy. To confirm this behavior, the transmittance and absorption of the glass need to be measured.

CONCLUSION

The energy generation of OPV panels has been studied and, in this work, this technology was submitted to realistic operating conditions, that is, outside the controlled laboratory environment, in an urban location. It was observed in this work that the panel that had a glass layer between it and the external environment presented a better electrical response during the evaluation period. The results obtained in this work demonstrate that OPV panels are a viable option for power generation, presenting considerable performance and diversifying the use of photovoltaics as an energy source.

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