Metrohm
Autolab B.V.

Autolab Application Note PV01

Photovoltaics
Part 1 – Dye sensitized solar cells

Keywords

Photovoltaic devices, dye sensitized solar cells (DSC)

Summary

A solar cell or photovoltaic cell is a device that converts light energy into electrical energy. Dye-sensitized solar cells (DSC) are currently subject of intense research in the framework of renewable energies as a low-cost photovoltaic (PV) device. Electricity generated from a PV produces zero emissions, is modular, and can produce energy anywhere the sun shines.

The standard characterization technique of a PV device consists in the determination of the DC Current-Voltage curves under different incident light intensities.

This application note illustrates the use of the Autolab PGSTAT302N in combination with the Autolab LED Driver kit to perform DC characterization of a PV device.

Hardware setup

The measurements described in this application note require the Autolab LED Driver. This kit is used to set the DC light intensity of the light source.

Experimental conditions

All the measurements were performed on a dye-sensitized solar cell, using the N719 dye, supplied by Solaronix. The light source was a triple LED array driven by the output current of the Autolab LED Driver. The output of the LED Driver is controlled by the DAC164 of the Autolab, directly from the software. All the measurements were carried out with the NOVA software.

Photocurrent-voltage measurements (617 nm)

The photocurrent-voltage measurements (iV curves) can be obtained by applying a potential scan, from 0 V (short-circuit conditions) to the open-circuit potential, under constant illumination.

Figure 1 shows the measured iV curves with increasing light intensity recorded at 617 nm (red-orange). As the light intensity increases, the maximum short-circuit current, i_{SC} and the open-circuit voltage, V_{OC} increase.

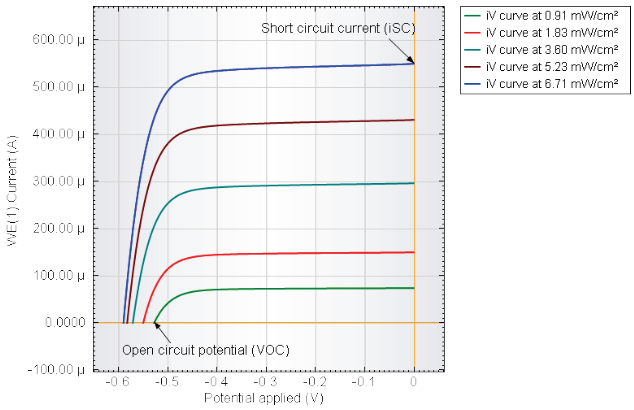

Figure 1 – iV curves recorded at 617 nm at different light intensities

Figure 2 shows the measured power versus voltage (PV) curves with increasing light intensity recorded at 617 nm. As the light intensity increases, the power and the maximum power point (MPP) increases.

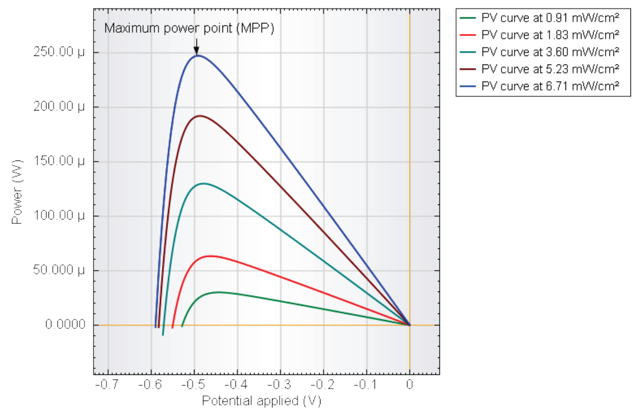

Figure 2 – Power/Voltage curves recorded at 617 nm at different light intensities

Photocurrent-voltage measurements (530 nm)

The same measurement can be repeated at a different wavelength (530 nm). Figure 3 and Figure 4 show the iV and the PV curves recorded under increasing constant illumination, with a 530 nm (green) light source.

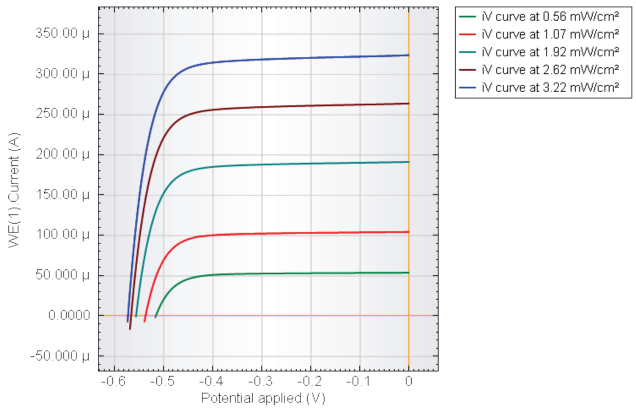

Figure 3 – iV curves recorded at 530 nm at different light intensities

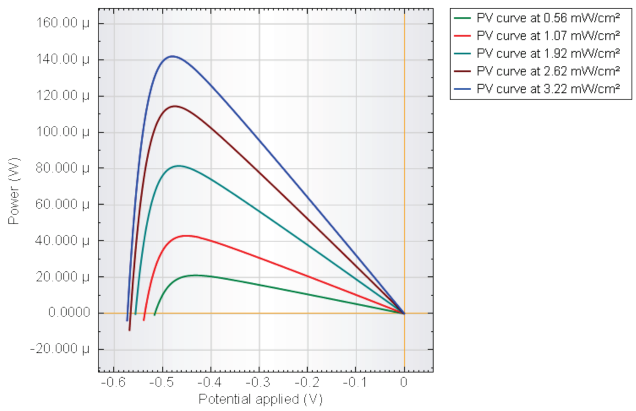

Figure 4 – Power/Voltage curves recorded at 530 nm at different light intensities

Comparison

The behavior of the cell at same light intensity is shown in Figure 5 and Figure 6. The curves are obtained using an illumination intensity of 2.29 mW/cm².

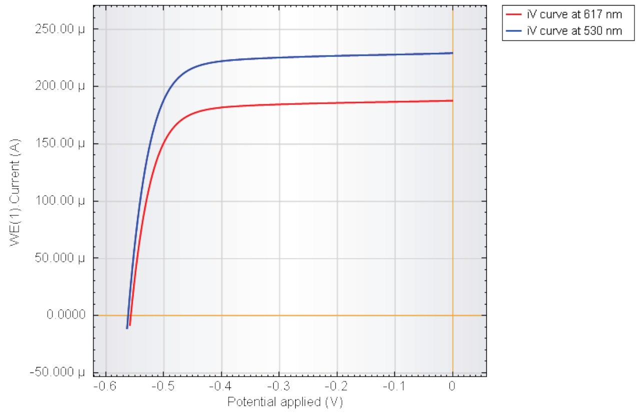

Figure 5 – Comparison of the iV curves recorded at 2.29 mW/cm² for 617 and 530 nm

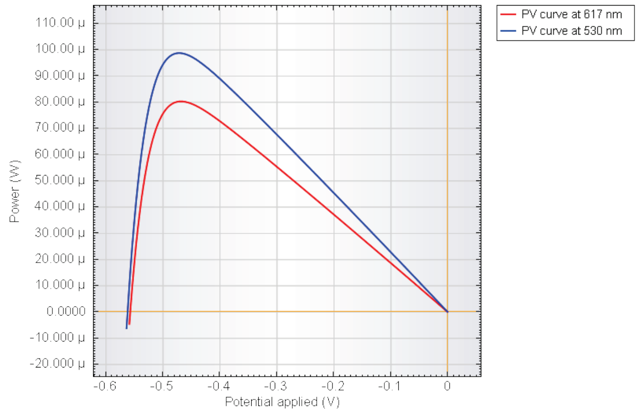

Figure 6 – Comparison of the PV curves recorded at 2.29 mW/cm² for 617 and 530 nm

530 nm is quite close to the reported wavelength for absorption maximum of the N719 dye used in this cell, which explains the significant differences between the measurements at 530 nm and at 617 nm.

Data analysis

From the iV (current-potential) and PV (power-potential) curves, the following parameters can be obtained:

- i_{SC} (Short-circuit current): the cell current measured at an applied potential of 0 V. i_{SC} is a function of the illumination intensity.
- V_{OC} (Open-circuit voltage): the cell potential measured when the current is 0 A.
- MPP (Maximum power point): the point where the maximum power is generated.
- FF (Fill factor): the ratio of the maximum power to the short and open circuit values.

According to the Schottky equation, both the short-circuit current, i_{SC}, and the open-circuit voltage, V_{OC} are dependent on the light intensity. The current at short circuit increases linearly as the light intensity increases, since the photon-to-current conversion rate increases. On the other hand, the open-circuit voltage increases logarithmically, following the distribution of the energy states in the semiconductor. The maximum power point, MPP, also increases linearly with the light intensity (see Figure 7 and Figure 8).

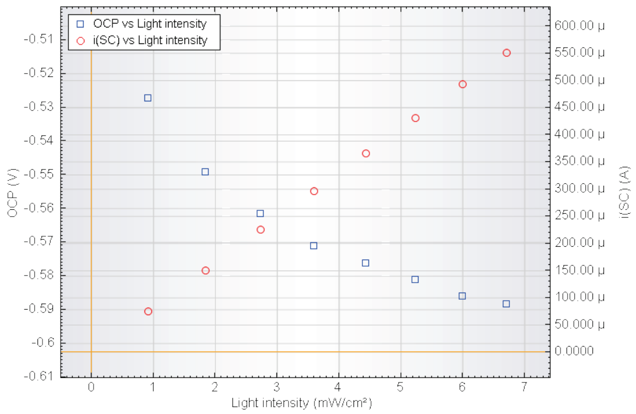

Figure 7 – Variation of V_{OC} and i_{SC} versus light intensity at 617 nm

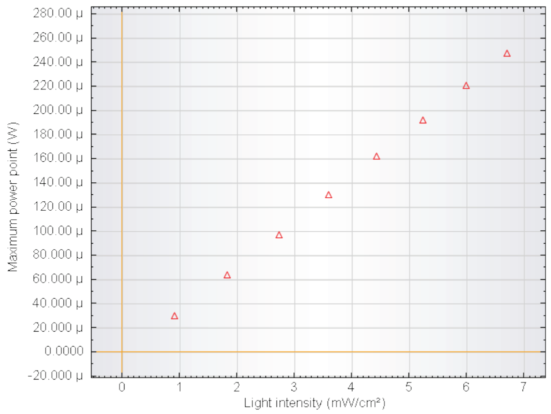

Figure 8 – Variation of the MPP versus light intensity at 617 nm

Figure 9 shows the evolution of the fill factor, FF versus the light intensity at 617 nm. The values fall within the normal range expected for this type of cells (average of 76.6 %). This value is the same at 530 nm.

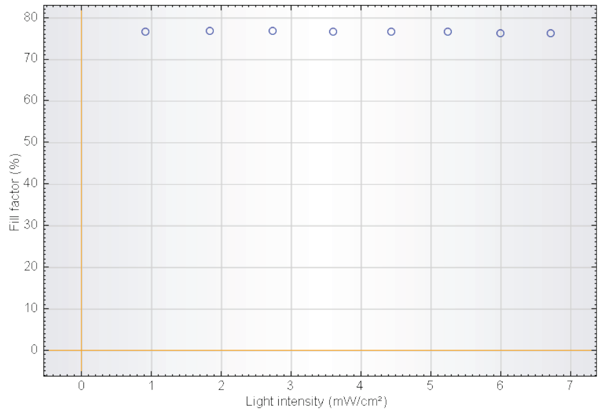

Figure 9 – Evolution of the fill factor (FF) versus the light intensity at 617 nm

Additionally, the following values can be calculates from the measured values:

- η, (Efficiency): the ratio of the developed power to the light intensity.
- $IPCE$ (Incident Photon-to-current conversion efficiency): the ration of the number of electrons generated in the solar cell to the photon flux on the photoactive surface area of the cell.

Figure 10 and Figure 11 show the evolution of the efficiency and the IPCE measured at 617 nm at different light intensities. The efficiency increases slightly as the light intensity increases while the IPCE remains more or less constant.

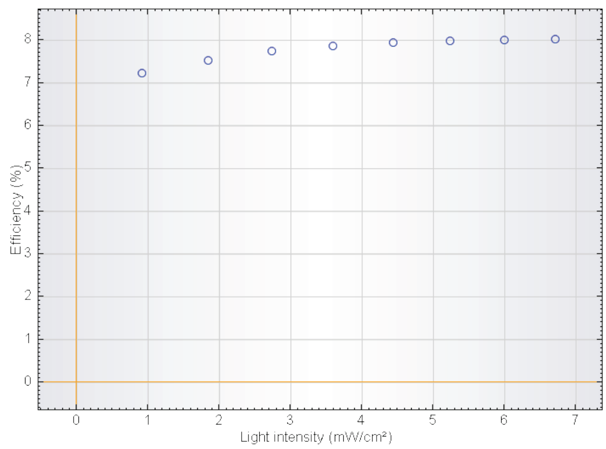

Figure 10 – Variation of the efficiency, η versus the light intensity

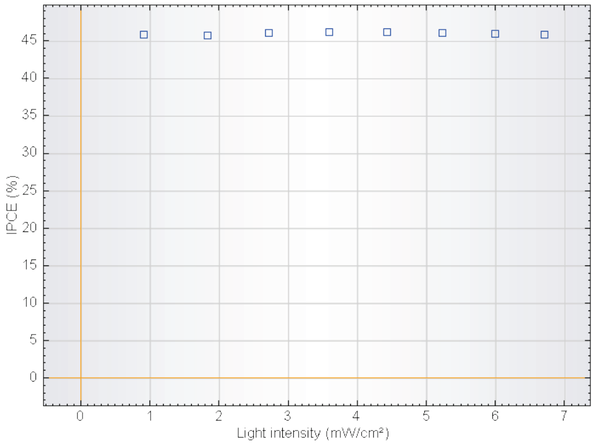

Figure 11 – Variation of the IPCE versus the light intensity

Conclusions

This application note has illustrated the use of the Autolab LED Driver kit to study the DC behavior of a dye sensitized solar cell. The NOVA software provides the possibility of calculating the typical performance indicators and plotting these versus the light intensity.

The cell can be studied under different light intensities and different wavelengths. From the recorded data, typical performance indicators can be determined.

Acknowledgments

J. Halme and K. Miettunen from the Helsinki University of Technology are gratefully acknowledged for their assistance.

Date

1 July 2012