ANTHOCYANINES AS LIGHT HARVESTERS IN THE DYE–SENSITIZED TIO2 SOLAR CELL

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1. Introduction

The first panchromatic film, able to remit image in black and white, followed the work of Vofel in Berlin, in which he used dyes and silver halide grains [1]. However, clear recognition and verification of operating principle dates to 1960s, when Gerisher and Tributsh researched a ZnO photoelectrode sensitized by organic dyes [2, 3]. But these cells had low harvesting efficiencies and low photon to current conversion, because as a photoelectrode they used single crystals and polycrystalline materials. Only after the introduction of mesoporous materials such as TiO_2 and using synthesized dyes the performance of these cells improved. By using porous TiO_2 electrodes with a roughness factor of ca. 1000 Ru based on a synthesized dye and iodine I^-/I_3^- redox couple in an organic solvent that Grätzel and O'Regan reported a solar cell with efficiency of 7 to 10 % [4]. Ever since this discovery there was a continuous approach to improve performance, efficiency and stability of these solar cells.

2. Structure and light driven charge transport in DSSC

In this paper anthocyanine extracted from blackberry was used instead of widely used dyes based on Ru and N3 complexes such as N3, N719 or "black dye", on which one of the highest efficiencies where measured (10.0 % to 11 %) [4, 5]. The structural formula for some N3 based molecules are in Figs. 1 and 2.

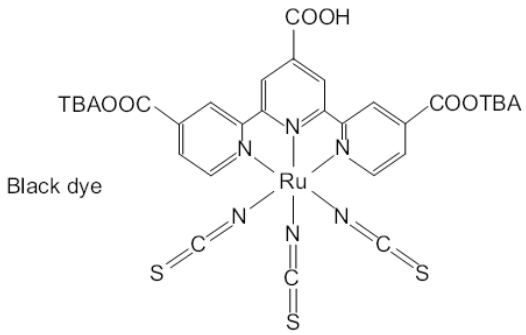

Fig. 1: *Structural formula of organic dye - "Black dye".*

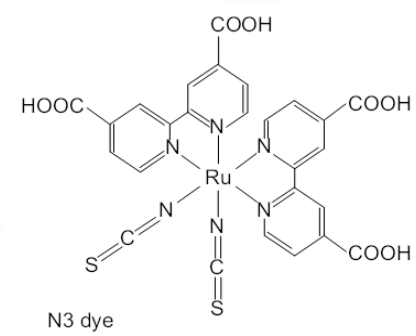

Fig. 2: *Structural formula of organic dye - N3.*

Although DSSC using these dyes can achieve high performance, there is a problem with Ru at the center of the molecule, whose price is very high and such molecules are artificially prepared which raises a cost of the final product even higher. Therefore, we decided to use antochyanine dye, which can be found in nature in abundance.

The structure of antochyanine is depicted in Fig. 3.

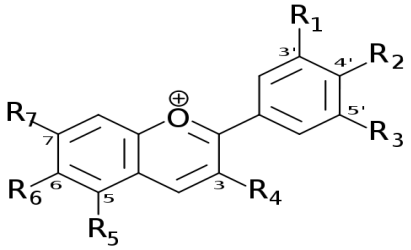

Fig. 3: *Structural formula of natural organic dye – anthocyanine.*

3. Characterization of the DSSC

The performance of a solar cell is defined by several parameters such as short-circuit current I_{sc} and open-circuit voltage V_{oc} obtained under standard illumination conditions (AM 1.5). Fill factor (FF) under standard conditions is a measure of a diode behavior of the cell. It is obtained using a full current-voltage characterization as follows:

$$FF = \frac{P_{max}}{V_{oc} I_{sc}} = \frac{(VI)_{max}}{V_{oc} I_{sc}} \quad (1)$$

The global power conversion efficiency of energy to electricity conversion efficiency (η) of the cell with Pout electrical power under standard illumination conditions is given by:

$$\eta = \frac{P_{out}}{P_{in}} = I_{SC} V_{OC} \frac{FF}{P_{in}} \tag{2}$$

where P_{in} is incident optical power.

The measurements of I-V curves were carried out using Keithley 5A Source Meter, Model 2440. The samples were illuminated by AM 1.5G solar simulator Oriel (Xe 1000 W, 250-1100 nm), class AAA. I -V characteristics of the solar cell are displayed in Fig. 4.

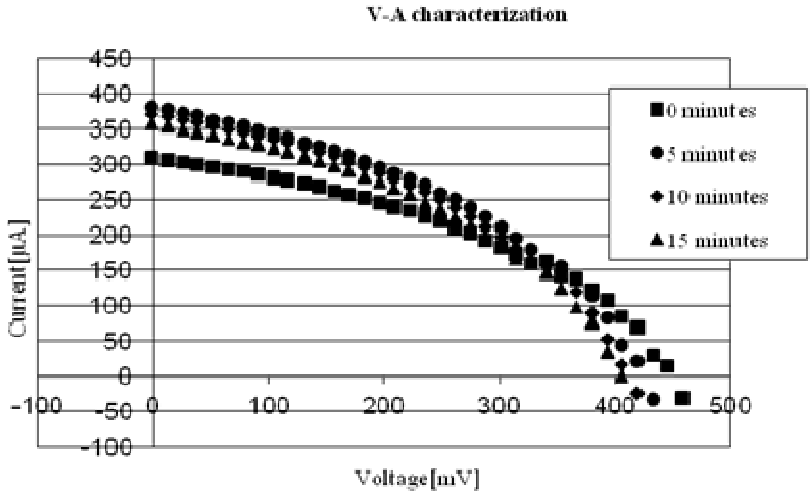

Fig. 4: *I-V characteristic of the experimental data.*

The measured and calculated parameters of the solar cell are in Tab. 1. From values in Tab. 1 can be seen that parameters of DSSC (V_{oc}, I_{sc}, V_m, I_m, FF and efficiency) are slightly degrading over time; degradation of the efficiency is of exponential character.

Tab. 1: *Degradation of solar cell's parameters.*

time	I_{sc}[μA]	U_{oc}[mV]	I_{max}[μA]	U_{max}[mV]	FF[%]	η [%]
0	308.94	445.5	202.74	275.0	40.51	0.0139
5	380.40	419.0	238.80	275.0	41.20	0.0164
10	371.52	406.0	238.74	261.5	41.39	0.0156
15	358.12	406.0	224.65	261.5	40.40	0.0147

4. Summary

DSSC were successfully fabricated using anthocyanine dye extracted from blackberries. The open circuit voltage of 419.0 mV, short circuit current of 380.40 μA, fill factor of 41.2 % and efficiency of 0.0164 % were evaluated. The cell shows degradation in performance over time of the exponential type with a drop in the open circuit voltage to 406 mV in 15 minutes.

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