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REINVESTIGATION OF BLUEBERRY ANTHOCYANINS FOR THE DYE-SENSITIZED SOLAR CELLS

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Abstract:

Natural dye-sensitized solar cells (DSSCs) have gained increasing attention and have been classified as feasible alternatives to conventional photovoltaic devices due to their many advantages, such as simple construction procedure, low cost of materials used, wide availability, their ecological nature, the use of non-toxic materials, etc. [1]. The main drawback of the DSSCs-based natural dyes is the low efficiency due in particular to the weak binding between natural dye molecules with titanium dioxide (TiO_2) film. High-efficiency dye-sensitized solar cells use the synthetic organic dyes which are most frequently anchored on metal oxide photoanode through the carboxylic group.

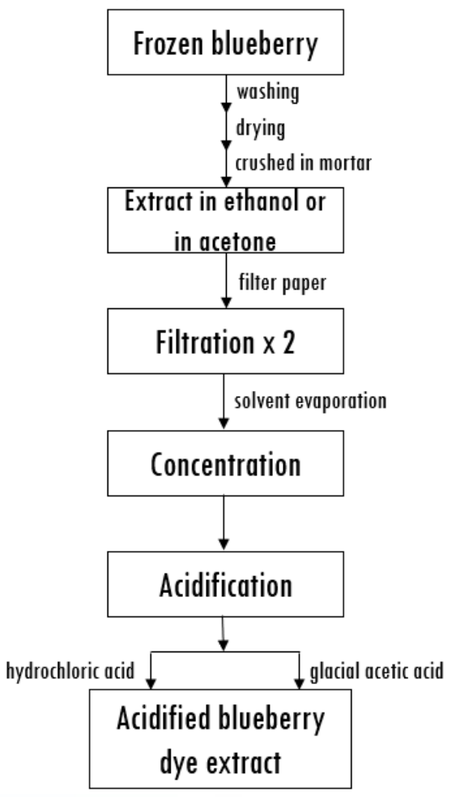
The natural selectivity of TiO_2 using the anthocyanins extracted from frozen blueberry fruits has been investigated for the improvement of the natural DSSCs. Herein, through the addition of the carboxyl group by the acidification of the crude blueberry extract with acetic acid was improved the immobilization of the adsorbent dye molecules onto the TiO_2 surface. Optical analysis and atomic force microscopy show the increase of the visible absorbance and the uniform anchoring of the natural dye molecules over the whole TiO_2 film causing a higher dye loading. DSSCs were fabricated using natural dye obtained by the acidification of crude blueberry extract with hydrochloric acid and acetic acid. Beneficial effect of the carboxylic groups in the immobilization of the natural dye molecules onto the surface of TiO_2 was confirmed by the best conversion efficiency of 0.722 % under the sunlight, achieved from the dye obtained by the acidification with acetic acid.

Aims:

- ✓ ththe improvement of the natural DSSCs
- ✓ e improvement immobilization of the adsorbent natural dye molecules onto the TiO_2 surface through the addition of the carboxyl group
- ✓ the natural selectivity of TiO_2 using the anthocyanins
- ✓ the improvement of power conversion efficiency (PCE)

Methods and Results:

• Athocyanins extraction



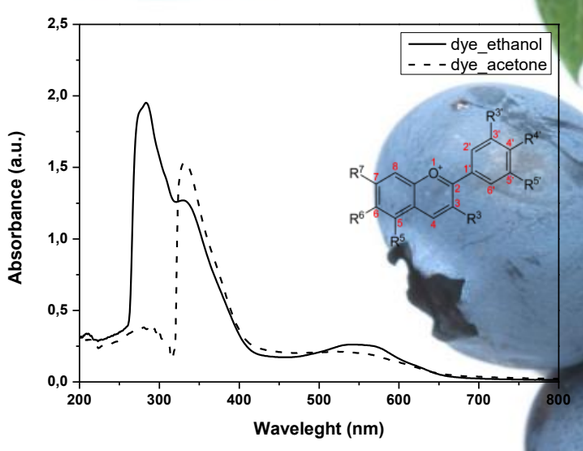


Figure 1. UV–Vis spectrum of anthocyanin extract solution using ethanol and acetone as solvent at room temperature

• Preparation of DSSCs

- ✓ The working electrode was prepared by depositing a thin film of TiO_2 paste on the conductive side of a fluorine-doped tin oxide (FTO) glass by the doctor-blade technique followed by calcination at 450°C for 1h.
- ✓ The TiO_2 coated FTO glass was subsequently dipped in diluted $TiCl_4$ solution for 1 hour at 70 °C and annealed at 450°C for 60 minutes.
- ✓ After, the films were immersed in the natural dye under dark, for 24 h.

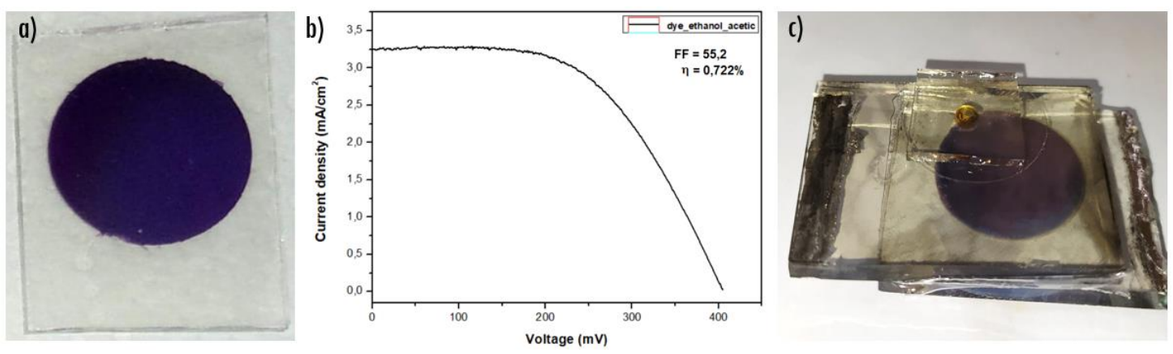


Figure 2. (a) Image of TiO_2 film sensitized with blueberry anthocyanin; (b) J-V curve of the n-type DSSC based on blueberry anthocyanin; (c) DSSC assembling

Methods and Results:

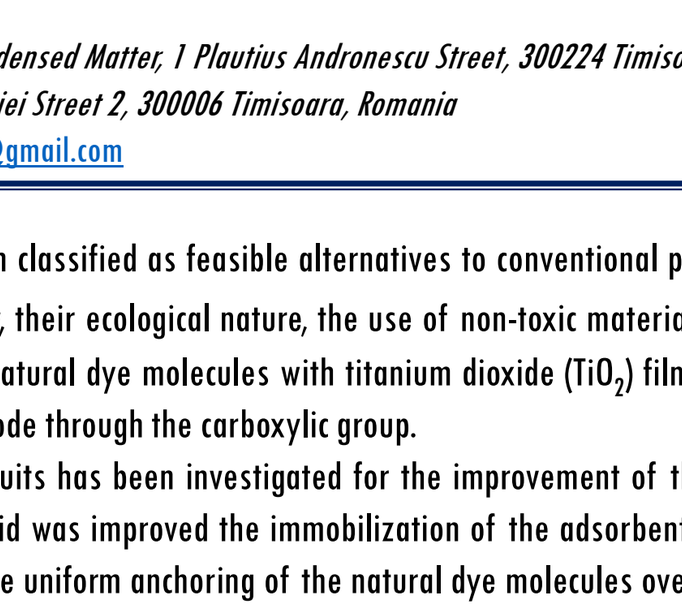


Figure.3. FTIR spectra of a) dye_ethanol sensitized TiO_2 film and b) dye_acetone sensitized TiO_2 film in KBr pellet

Catalytic counter electrodes were obtained by the thermal decomposition of the H_2PtCl_6 solution on FTO-coated glass at 400 °C for 30 min.

In order to obtain the I^-/I_3^- electrolyte solution 0.5 M KI, 0.03 M I_2 were added in ethylene glycol and acetonitrile with a volume ratio of 4:1. A 60μm thick spacer Meltonix 1170-60 was used in order to fix together the TiO_2 photoanode with the platinized counter electrodes, followed by the injection of electrolyte into the space between the electrodes. A Keithley 2450 SourceMeter SMU Instruments was used to measure the solar cell performances under AM 1.5G simulated sunlight (1000 W/m²).

Conclusions:

- ✓ Was investigated the immobilization of the adsorbing dye molecules onto the surface of TiO_2 by the addition of the carboxyl groups;
- ✓ The properties of the crude blueberry extract acidified with acetic acid were investigated via colorimetric analysis, atomic force microscopy, UV-Vis and Fourier transform infrared spectroscopy;
- ✓ The enhanced binding strength between natural dye molecules with TiO_2 affected positively the PCE of the anthocyanin-sensitized solar cells;
- ✓ The best DSSC yielded a :
  - high short-circuit current density J_{SC} of 3.23 mA/cm²,
  - an open-circuit voltage V_{OC} of 0.405 V,
  - a fill factor FF of 55.2% and
  - a power conversion efficiency PCE of 0.722 % under the sunlight, representing the highest record reported so far for similar photoanode preparation.

Acknowledgement:

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References:

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