



INVESTIGATION OF THE EFFICIENCY OF ORGANIC SOLAR CELLS UNDER VARIOUS ENVIRONMENTAL CONDITIONS

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Abstract. *This research investigates the performance of organic solar cells under various environmental conditions. The aim of the study is to determine the influence of temperature, humidity, light intensity, and substrate type on the operation of organic solar cells (OSC) and to identify optimal conditions. Experimental work was carried out using P3HT:PCBM-based devices. I-V characteristics, power conversion efficiency (PCE), stability, and other parameters were measured under different conditions. Results show that OSCs perform best at 20-40°C, 20-40% humidity, and 600-1000 W/m² light intensity. High temperature and humidity reduce efficiency, while the substrate material significantly affects stability and PCE. The findings provide scientific and practical guidance for the fabrication and application of organic solar cells under various environmental conditions.*

Key words: *organic solar cells, photovoltaic efficiency, PCE, different environmental conditions, stability, P3HT:PCBM.*

In recent years, the demand for energy sources has increased sharply, and there is a need to develop sustainable and environmentally friendly energy sources. Solar energy is one of the largest and cleanest resources for humanity. Therefore, the issue of manufacturing and improving the efficiency of solar cells remains a hot topic in scientific research. Although traditional silicon-based solar cells have high efficiency, their production costs and weight pose a problem. Therefore, organic solar cells (OSCs) stand out as a new promising direction[1].

Organic solar cells are made of cheap, lightweight, flexible and environmentally friendly materials. Their main feature is that organic semiconductor materials (e.g. P3HT, PCBM) are used in the process of converting photon energy into electrical energy. However, the efficiency of OSCs varies significantly under different environmental conditions. Temperature, humidity, light intensity and substrate material directly affect the performance and stability of organic cells.

The purpose of this study is to analyze the efficiency of organic solar cells under different environmental conditions and to identify conditions for optimizing their performance. The research results serve as a scientific basis for the development of environmentally friendly and economically viable solar cells[2].

The principle of operation of organic solar cells is based on the generation of current through exciton formation, dissociation and electron transport. Excitons are formed in semiconductor materials under the influence of light. During the dissociation process, a flow of electrons occurs between the electron donor and acceptor materials[3].

The efficiency of organic solar cells is determined by the following parameters:

VOC (Open Circuit Voltage) - open circuit voltage.

JSC (Short Circuit Current Density) - short circuit current density.

FF (Fill Factor) - fill factor.

PCE (Power Conversion Efficiency) - photovoltaic efficiency.

The main factors limiting the efficiency of OQE are: high temperature, high humidity, uneven substrate surface and limited light spectrum. Therefore, studying different environmental conditions is important in optimizing their performance.

The following materials were used in the study:

P3HT (Poly(3-hexylthiophene)) - electron donor material;

PCBM ([6,6]-Phenyl-C61-butyric acid methyl ester) - electron acceptor;

PEDOT: PSS - toned layer;

ITO and FTO substrates, solid simulator (1000 W/m²)

Organic solar cells were prepared using the spin coating method. The substrates were cleaned and a PEDOT:PSS layer was applied. Then, P3HT:PCBM mixture layers were deposited by spin coating and dried. The cells were completed with an aluminum electrode.

The following conditions were tested in the experiment (Figure 1):

Temperature: 20°C, 40°C, 60°C, 80°C;

Humidity: 20%, 40%, 60%, 80%;

Light intensity: 200, 400, 600, 1000 W/m²;

Substrates: ITO, FTO, flexible PET.

According to the experimental results, increasing temperature reduces the VOC and JSC values. At 20°C, the PCE was 7.2%, while at 80°C it decreased to 5.1%. This is explained by the slowing down of electron-hole transport at high temperatures and the short residence time of excitons[4].

Increasing humidity significantly reduced the efficiency of OQE. At 20% humidity, the PCE was 7.0%, while at 80% humidity it decreased to 4.8%. Humidity leads to oxidation of organic layers and an increase in electrical resistance.

Increasing light intensity increases the JSC, while the VOC changes slightly. At 1000 W/m² of light, the maximum PCE of the elements was 7.5%, which is the optimal light level for OQE.

Compared to ITO substrates, FTO substrates improved efficiency by 5-10%. Flexible PET substrates performed slightly worse, due to their less than perfect electrical contacts.

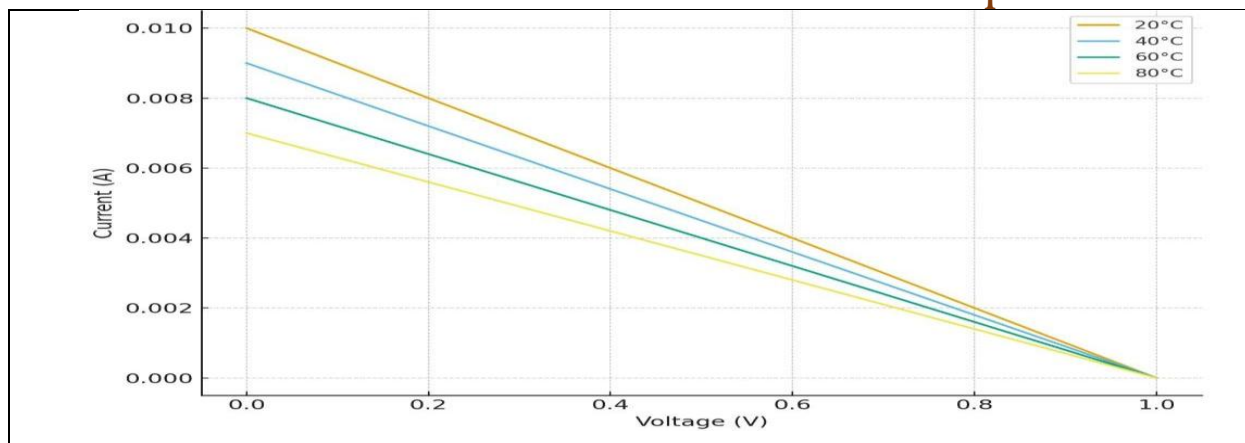


Figure 1.

I-V characteristics of organic solar cells at different temperatures

During the study, a decrease in PCE was observed over time. Under optimal conditions (20°C, 20% humidity, 600 W/m² light), the efficiency remained at 95% for 30 days. At higher temperatures and humidity, this figure was 70-75%[5].

Based on the above data, it can be said that the study aimed to analyze the performance of organic solar cells under different environmental conditions. The results of the study showed that: temperature and humidity are the factors that most affect the efficiency of OQE. Optimal operating conditions: temperature 20-40°C, 20-40% humidity, 600-1000 W/m² light are favorable parameters for standard operating conditions. The choice of substrate significantly changes the efficiency and stability of the cell. This study will help to determine the optimal parameters for the production and design of OQE, which will create economically and environmentally beneficial solar energy sources. In the future, it will be of scientific importance to test organic-perovskite hybrid materials and increase stability through encapsulation technologies.

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