**The Effect of Illumination Time on the DSSC Performance Parameters**

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| **Abstract**The study of dye-sensitized solar cells (DSSCs) has been ongoing for the last thirty years in view of different aspects. One of the shortcoming of DSSCs is the lack of comprehending of how to engineer their different components. The working electrode, mesoporous layer, dye, electrolyte, and platinum coating on counter electrode are a few of the fundamental research items of DSSCs that may be categorized. In addition to these research items, the effect of production and operating conditions on a solar cell performance parameters are being examined. One of the operating conditions that has a direct impact on the performance characteristics of the solar cell device is its illumination time under a solar simulator. In this study, the effect of illumination time on the performance metrics of a solar cell such as short circuit current density (*JSC*), open circuit voltage (*VOC*), fill factor (*FF*), and power conversion efficiency (PCE) was investigated and the obtained results were reported. In order to test the performance of the DSSC devices, samples were exposed to different illumination periods for 0, 30, 60, 90, 120, and 150 s. As a result, with an efficiency of 3.74%, the sample that was not exposed to light for a long amount of time showed the maximum efficiency, while the sample that was exposed to light for 150 s showed the lowest efficiency of 3.23%. |
| Keywords: Energy, renewable energy, solar energy, DSSC, efficiency. |

1. **Introduction**

It is undeniable fact that energy has a major role in the advancement of science, technology, and civilization. Many studies have been conducted on the creation of clean renewable energy resources as a way to lessen the negative environmental consequences of carbon based fuels and growing global energy demands. Among all the renewable energy sources, solar energy is the most popular because of its abundant supply and minimal impact on the environment. The solar energy system generates electricity from sunlight without emitting any gases that might accelerate global warming. Dye sensitized solar cells (DSSCs), a third generation solar cell, have been a prominent and frequent study topic among the many forms of solar energy studies [1-7].

In a DSSC, power conversion efficiency (PCE) is one of the most important parameter that determines the device performance. And the ‘fill factor’ or simply ‘*FF’* is a metric that helps to define the maximum power that a solar cell can produce. As can be observed in Eq. (1), the *FF* is defined as the ratio of the solar cell’s maximum output to the product of *VOC* and *JSC*.

$FF=\frac{J\_{mp}V\_{mp}}{J\_{sc}V\_{oc}}$ (1)

By using this *FF value*, the power conversion efficiency ($η$) of device can be calculated as given in Eq. (2) below.

$η=\frac{P\_{max}}{P\_{in}}=\frac{J\_{mp}V\_{mp}}{P\_{in}}=\frac{J\_{sc}V\_{oc}FF}{P\_{in}}$ (2)

The parameters given in Eq. (1) and (2) can be defined as below;

$J\_{mp}$ : Current density at maximum power (mA/cm2)

$V\_{mp}$ : Voltage value at maximum power point (V)

$J\_{sc}$ : Short cicuit current density (mA/cm2)

$V\_{oc}$ : Open circuit voltage value at maximum power (V)

$P\_{max} $: Maximum output power (mW/cm2)

$P\_{in}$ : Inpur power (100 mW/cm2)

In this work, considering these basic parameters, the effect of illumination time on the performance parameters of a dye-sensitized solar cell was studied.

1. **Materials and Methods**

Fluorine doped tin oxide (FTO) layer was employed as a base layer for the manufacturing of solar cell devices. The TiO2 paste was prepared using the Atilgan’s formula as described in their paper [5] before the TiO2 mesoporous layer coating procedure. Initially, ethyl alcohol and deionized water were used in order to wash the FTO glasses. Then, it was dried with the aid of an air pump after being disinfected in an ultrasonic bath. On clean FTO glasses, a TiO2 mesoporous layer was coated with a spin coating machine before being baked at 450 °C for about 25 minutes. To mitigate the recombination of electron hole pair, a thin TiCl3 blocking layer was coated by chemical bath method. Following the annealing stage, the TiO2 and TiCl3 coated samples were submerged in N719 dye solution and left for 18 hours to complete the dye loading procedure. Then, the performance measurements of assembled DSSC devices were executed by exposing the samples to various illumination times as 0, 30, 60, 90, 120, and 150 seconds as seen in Figure 1. So, the effect of illumination time on the performance parameters of a DSSC was studied and evaluated.



**Figure 1.** Illustration of solar cell device structure exposed to illumination.

1. **Results and Discussion**
	1. **The Absorbance and Transmittance Spectra**

The absorbance and transmittance spectra of dye loaded samples are given in Figure 2. As seen in Figure 2, the transmittance value in the region of 200-400 nm wavelength is quite low and is due to TiO2 coating and dye loading. It can be seen that absorbance values are reaching up to highest value at this region.



**Figure 2**. Representation of UV-Vis spectra of dye loaded sample.

* 1. **The J-V Measurement Results and Power of the Devices**

The J-V measurement results of devices were given in Figure 3. In accordance to the varying illumination time, it can be inferred that prolonged illumination time deteriorating the solar device performances. It is clear that illumination time of 150 s exhibiting minimum short circuit and open circuit voltage values. Now that, increasing illumination time causes the device warming much and increasing thermal losses in solar cell.



**Figure 3.** J-V results of samples exposed to different illumination periods.

As seen in Figure 3, the performance values were the higher for the device exposed to light for a short time. Consistent with these results, the power values of the devices gave similar results. So that, the maximum output power obtained for about 3.74 mW/cm2 obtained for the sample not exposing to illumination for a long time as seen in Figure 4.



**Figure 4.** Pout-V results of samples exposed to different illumination periods.

Figure 5 shows the PCE change in accordance to illumination time of the devices. According to the graph in Figure 5, it is obvious that PCE is gradually decreasing with the increasing time.



**Figure 5.** Power conversion efficiency variation with respect to illumination time.

Detailed performance parameters of DSSCs were given in Table 1. Results presented in Table 1 are well consistent with the J-V and output power values.

**Table 1:** Photovoltaic performance parameters of the DSSCs for different illumination time.

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| --- | --- | --- | --- | --- |
| Illumination time (s) | *FF* (%) | *JSC* (mA/cm2) | *VOC* (V) | *η* (%) |
| 0 | 0.655 | 9.35 | 0.60 | 3.74 |
| 30 | 0.621 | 8.84 | 0.61 | 3.35 |
| 60 | 0.619 | 8.93 | 0.60 | 3.34 |
| 90 | 0.617 | 8.87 | 0.60 | 3.29 |
| 120 | 0.617 | 8.89 | 0.59 | 3.28 |
| 150 | 0.619 | 8.76 | 0.59 | 3.23 |

1. **Conclusion**

In this study, to make a dye-sensitized solar cell, TiO2 mesoporous layer was coated onto a fluorine-doped tin oxide (FTO) layer with spin coating machine. Then, TiCl3 thin film layer was coated with the chemical bath method as a blocking layer for this device. In order to see the effect of illumination time on the performance parameters of the solar cell, the samples were exposed to light for different periods of time. According to the results, the efficiency values are decreasing while illumination time increases. On the other hand, there is a notable degradation in *FF* while *VOC* values of the devices don’t show a remarkable change. The sample, which was not exposed to light for a long time, displayed the highest efficiency of 3.74%, meanwhile the sample exposing light for 150 s exhibited the worst efficiency of 3.23%. Thermal losses in the device increased as a result of prolonging illumination on the device surface. As a result, both the *FF* and *JSC* values were degraded, and the PCE of the device was also decreased. It is expected that this study will shed light on other scientists who will study the lifespan and sustainable efficiency of solar devices exposed to light for a long time.

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