Small Scale DSSC Panels Design and Its Performance

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Abstract. This study reports an effort to design dye-sensitized solar cell (DSSC) panels. The panel was proposed using a TiO$_2$ layer, dye, electrolyte and counter electrode. TiO$_2$ layer was deposited on FTO glass by using spray methods then it was heated on the furnace for 45 minutes. We applied ruthenium dye (N719), iodolyte and platinum as a counter electrode. Performance of solar cells was characterized by solar illumination using a multimeter. The solar’s intensity was measured by using a solar power meter. It was found the efficiency and fill factor of DSSC about 2.08% and 0.80, respectively. This study can be scaled up then applying in daily life.

Keywords: DSSC, panel, efficiency, fill factor and scale up

1. Introduction
The development of solar cell research, which can convert photon energy from the sun into electrical energy, as very rapid alternative energy is done [1-11]. In the first generation, solar cells are made from semiconductor crystals, while the next generation uses thin layer semiconductors (amorphous silicon). In the last decade also developed more economical solar cells, namely organic solar cells.

Dye-sensitized solar cell (DSSC), first discovered by Gratzel et al., is one of the organic solar cells with oxide semiconductor materials, dye, electrodes, electrolyte solutions that attract the attention of many people. The organic material commonly used in DSSC solar cells is titanium dioxide (TiO$_2$). The TiO$_2$ material is an n-type semiconductor that has a wide bandgap (about 3.2 eV). Many researchers report good solar cell performance by optimizing the TiO$_2$ layer, dye, electrolyte and counter electrode. In our previous research [12-15], we found that the efficiency of solar cells is still low at about 1%.

Many obstacles are encountered in the development of DSSC solar cells. One of them is the price of expensive components, not environmentally friendly and complicated fabrication process. However, to date, most of the developed DSSC solar cells are still in a laboratory scale so they can not be applied widely.

In this study, we report on our initial research to create DSSC panels. In this study, we use some simple methods, such as spray so that the resulting panel can be of low cost. We hope that the results of this research can be the basis for the development and application of DSSC solar cells in the community.

2. Materials and Methods
TiO$_2$ films were deposited on ITO substrates (10 Ω/cm$^2$) using a spray method. A suspension was prepared by dispersing 5 g of TiO$_2$ into 10 mL of distilled water, followed by stirring for 45 min. The homogeneous suspension was coated on the ITO surface, which was maintained at a temperature of approximately 150 ºC to evaporate the water [10]. The film was then heated at 450 ºC in a furnace for
45 minutes to strengthen the contact between the TiO$_2$ particles and the contact between the TiO$_2$ particles and the substrate. Synthetic (N719) dye was used in this research. The heat-treated TiO$_2$ films were immersed in this dye solution for 24 hours and then cleaned with distilled water before finally being heated at 40 °C for 10 minutes. Prototype solar cells were made by sandwiching HI-30 iodolyte solution (Solaronix, Switzerland) containing I$^-$/I$_3^-$ ion between a dye-impregnated TiO$_2$ film and a platinum-coated ITO electrode.

3. Results and Discussion

Structure of DSSC can be seen in Fig. 1(a) [13]. The mechanism that occurs in DSSC solar cells starts when the photons come on the dye so that the electrons are injected into TiO$_2$. The electrons then flow in the circuit and move to the counter electrode. The iodine-containing electrolytes then receive the electrons and pass them back to the degenerated dye [14-15].

![Diagram of DSSC solar cells](image)

**Figure 1.** (a) Mechanism and (b) band diagram of DSSC solar cells.

Figure 1b shows the band diagram of DSSC solar cells, where the desired process is marked by the green line (1) electron injection, (2) the collection of electrons, and (3) dye regeneration. On the contrary, it also shows the unexpected process, which is signed by red lines, namely: (4) decay, (5) recombination and (6) recaption reaction [12-15].

In this paper, we proposed a DSSC panel by employing ruthenium dye (N719), iodine electrolyte and platinum. The absorbance spectrum of this synthetic dye can be observed in Figure 2. The maximum peak of N719 was 313 nm, 393 nm, and 533 nm. Thus, the spectrum of sunlight can be well absorbed so that DSSC solar cell performance becomes better.

![Absorbance spectrum of N719 dye](image)

**Figure 2.** The absorbance spectrum of N719 dye.
The dimension of the DSSC panel was 10 x 10 cm as shown in Figure 3(a). I-V characteristic of the DSSC panel was measured under sunlight illumination. Efficiency and fill factor of the DSSC panel was 2.01% and 0.80, respectively. We suspect that the high internal resistance of solar cells is caused by conductive glass, ionic conductivity, and counter electrodes. However, the results obtained are better when compared with the studies conducted by our previous team [12-15].

In this work, undesirable processes such as recombination still occur so that the performance of solar cells is not optimum. In a subsequent study, we attempted to increase the efficiency of solar cells by optimizing some parameters such as (1) TiO$_2$ particle size, (2) electrolyte conductivity and (3) better dye absorbance. One of the things that solar cells need to have is long-term stability. Thus, in our future study, we attempted to use an electrolyte polymer that can improve its performance.

4. Conclusion
We have successfully proposed DSSCs panel by using TiO$_2$ nanoparticle, ruthenium dye, iodolyte, and platinum. It was found the efficiency and fill factor of DSSC about 2.08% and 0.80, respectively. The small DSSC panels (its dimension is about 10 cm x 10 cm) with sandwiched structured are expected to develop in large scale and applied in real life.

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