Kanazawa Izumigaoka High School03

Generating Eco-friendly Power
The Best Conditions for Dye-sensitized Solar Cells

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Abstract

Dye-sensitized solar cells are inexpensive and have the ability to generate electricity efficiently under indoor light.

Therefore, we tried to find the conditions under which they work the most efficiently.

We researched the relationship between voltage, cell size and the surface area of titanium oxide.

The results showed there is no relationship between voltage and the surface area, but the solar cells are capable of using 30-40 percent of the light energy.

In conclusion, our hypotheses were wrong, but there was a certain relationship between absorptivity of light and voltage. We think more people should use Dye-sensitized solar cells in their houses.

１．Introduction

Have you heard about Dye-Sensitized Solar Cells? It is a notable power source for sustainable energy. They generate electricity by oxidation and reduction, so they are different from silicon solar cells. They do generate more electricity than silicon solar cells in dim lights, such as domestic lights (figure1). And, they are cheaper than silicon solar cells. So, there are a lot of reasons we want to use them. However, it has poor efficiency currently. So our group researched the best conditions for generating electricity in an effort to make them more popular all over the world. Electricity is produced when light hits a transparent electrode. We will discuss this in more detail in the method section.

In previous studies, relationships between coloring matter and power generation were researched. Instead of this, our group decided to research the best conditions by clarifying the relationships between power generation and conditions such as absorptivity of light, surface area of titanium oxide (TiO_2), and illuminance.

In our first experiment, we tried to find out the relationship between voltage and absorptivity of light. We expected voltage to be proportion to the absorption percentage of light. But it becomes a constant after a certain percentage. Until a certain absorption rate, TiO_2 particles do not stack with each other, so all particles absorb coloring matter. However, beyond a certain rate, they start to stack and the number of particles which are not absorbed increases. They are reflected by the light.

In the second experiment, we expected voltage would be in proportional to the area.
We looked at the relationships between the electric current voltage and the size of Dye-Sensitized Solar Cells.

In our third experiment, we looked at the relationship between illuminance and the electric current voltage.

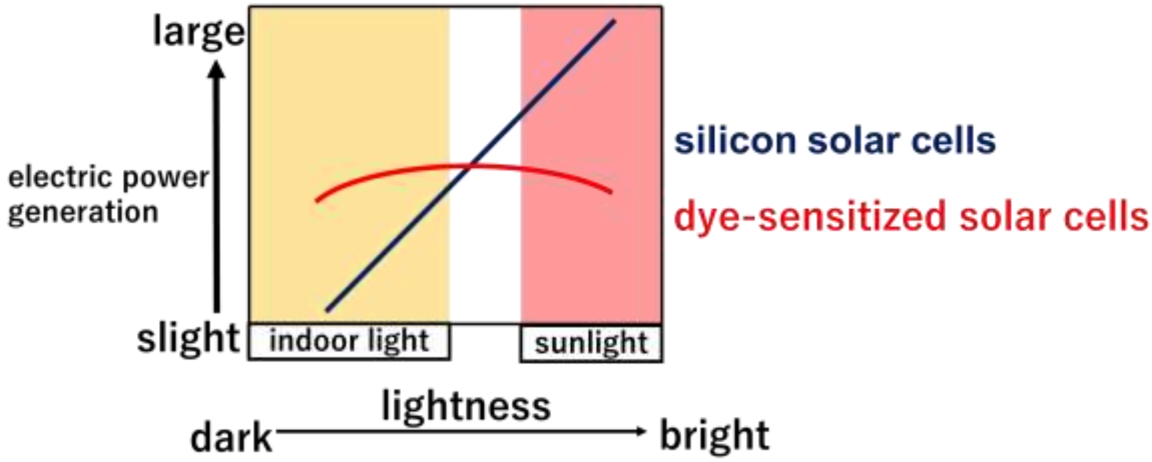

Figure 1

2． Method

We will introduce the mechanism of dye-sensitized solar cells and how it works.

First, light hits a transparent electrode. An electron is produced and travels via a conductor (electrical cord) to a stainless steel sheet. The electron then forms an Iodine ion. The Iodine ion breaks down back to Iodine and gives an electron to TiO_2. And the cycle is repeated to form electricity.

We will also introduce how to make dye-sensitized solar cells.

First, we applied TiO_2 paste to transparent electrode, and dried it. Then, we added four drops of coloring matter, and dried it again.

Next, we applied graphite and added drops of electrolytes to a stainless steel sheet.

Finally, we put together a transparent electrode and a stainless steel sheet. Fastening them with clips, so it would be ready.

We conducted three experiments.

Experiment 1: The relationship between absorptivity rate of light and voltage.

(Absorptivity rate of light is the percentage of light that is absorbed.)

1. Instruments: We used a transparent electrode, a stainless steel sheet, graphite, TiO_2 paste, electrolytes, organic coloring matter, clips, a glass stick, a pipette, a multimeter, a conductor, scotch tape and an illuminometer.
2. How to conduct the experiment: We connected the cell, a conductor and multimeter, and exposed it to light. And then, we measured the voltage.

   When we conducted this experiment, we changed its absorptivity rate by changing the thickness of the TiO_2 paste, and looked to see whether there is a relationship, or not. During the experiment we also measured the illuminance.

Experiment 2. The relationship between absorptivity rate of light and voltage.
Instruments: Experiment 1 instruments plus an ammeter and rheostat

1. How to conduct the experiment: As mentioned above, we connected the cell, a conductor, and multimeter, and exposed it to light, and measured the voltage.
   After measuring the voltage, we connected the cell, a conductor, an ammeter, and a rheostat, and exposed light to it. Then we measured the electric current.
   When we conducted this experiment, we changed the area of TiO_2 paste, and looked at whether there is relationship, or not.

Experiment 3. The relationships between illuminance and the electric current voltage.

1. Instruments: the same as experiment 2.
2. How to conduct the experiment
   The way we measured electric current voltage was the same as in experiment 2 except we changed the illuminance by changing angle and the distance between the cells and the light source.

3. Result

Experiment 1: The relationship between the absorptivity rate of light and voltage.

We were able to get the graph like Figure2. It showed that the maximum voltage existed when the absorptivity rate of light is between 40% and 60%. When the absorptivity rate of light is lower than 40%-60%, the voltage is in proportional to the absorptivity rate. On the other hand, when the absorptivity rate of light is higher than 40%-60%, the voltage gradually decreases.

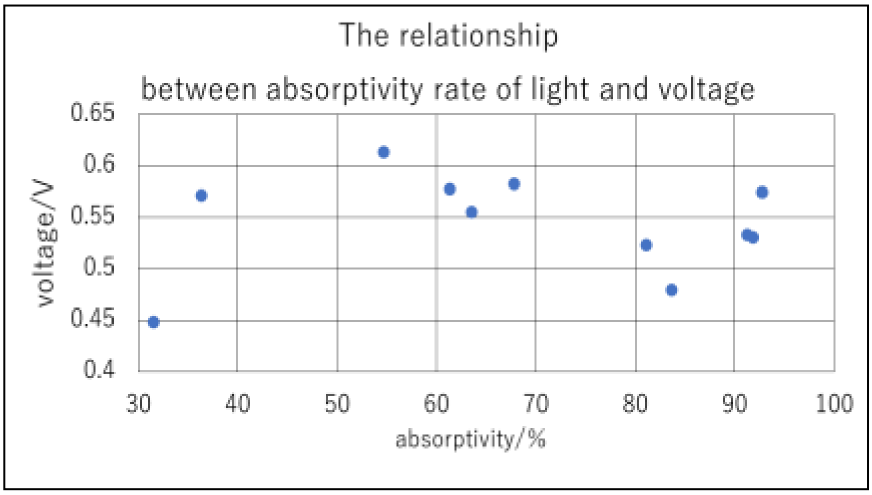

Figure 2

Experiment 2: The relationship between the absorptivity rate of light and voltage.

We were able to get the graph like Figure 3.4.5. It showed that the voltage was constant regardless of the area of TiO_2 paste, while the electric current was in proportion to the area of TiO_2 paste.

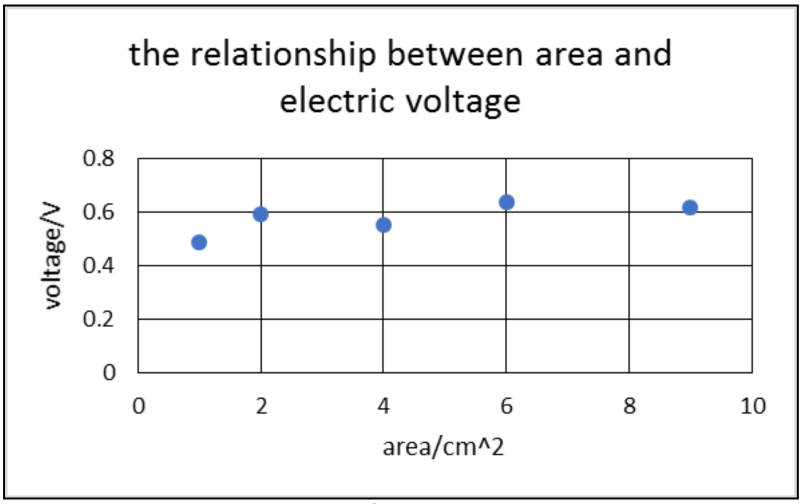

Figure 3

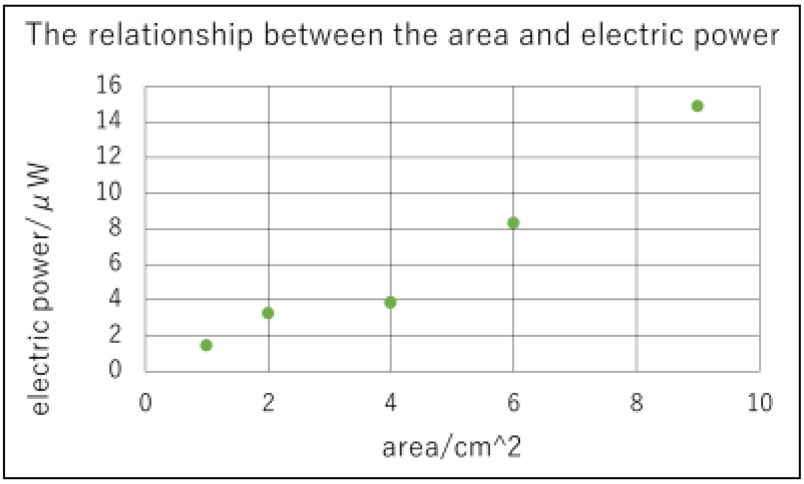

Figure 4

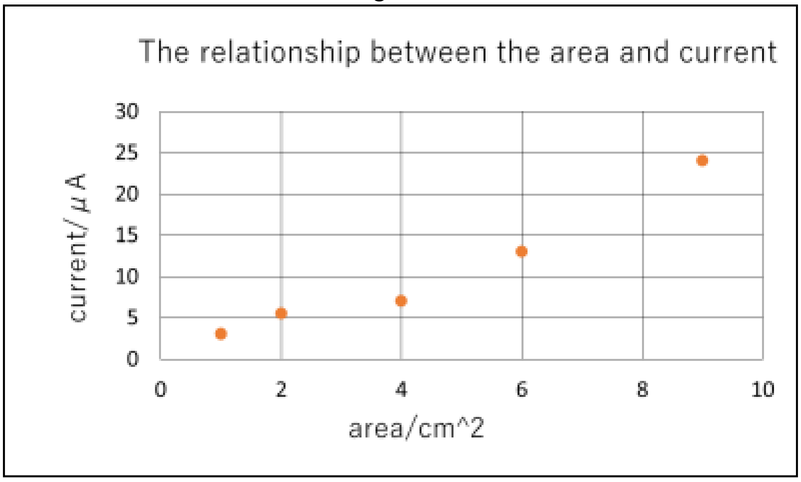

Figure5

Experiment 3: The relationships between illuminance and the electric current voltage.

We were able to get the graph like Figure 6.7.8. It showed that the electric current and the electrical power were in proportion to illuminance, while the voltage was constant.

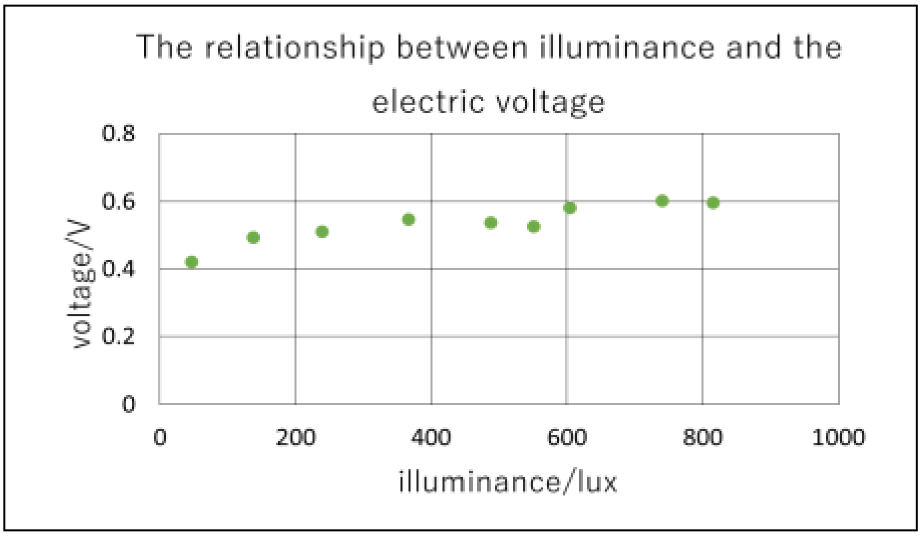

Figure6

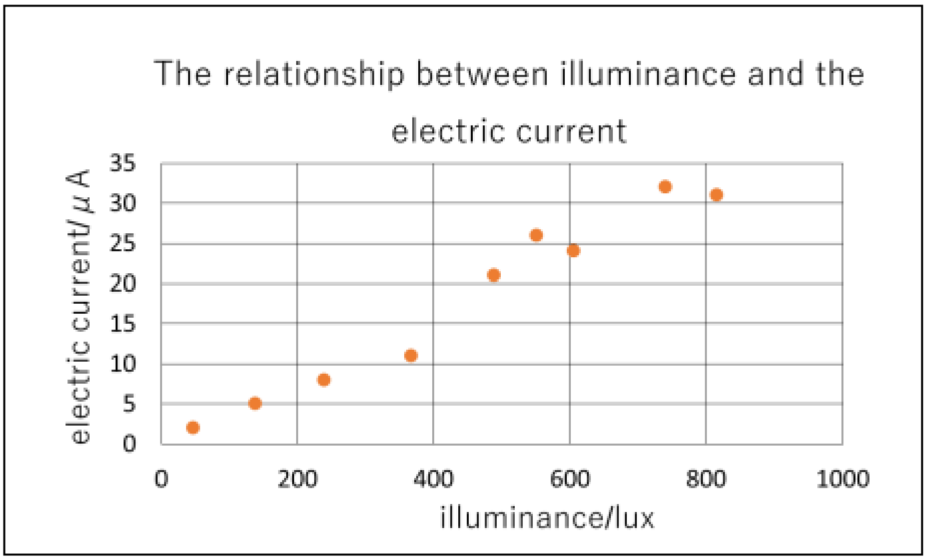

Figure7

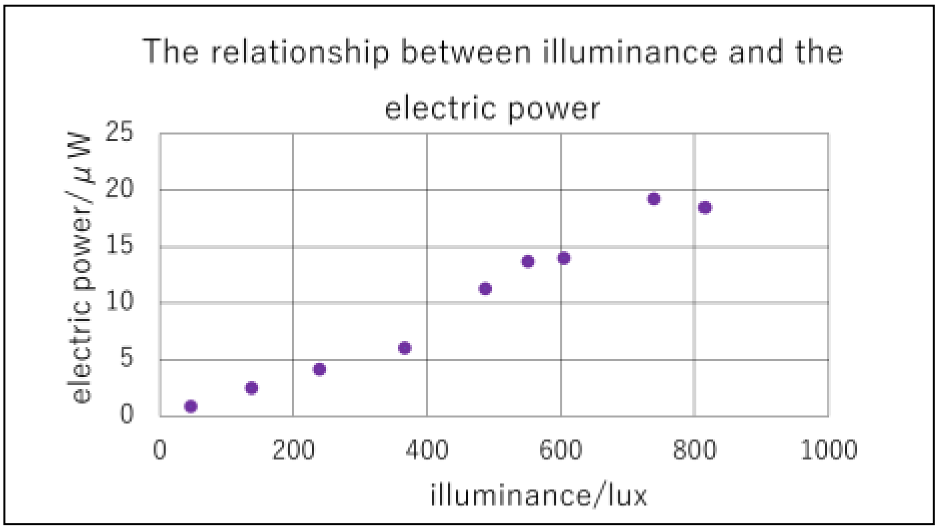

Figure8

4. Consideration

Experiment 1: The relationship between the absorptivity rate and voltage

From this result, we focused on the electron's movement.

When electrons accept the light, electrons get much energy, and then move to the electrode via TiO_2 particles. Then, TiO_2 particles work as resistance, so the electromotive force goes down. Accordingly, the larger the number of TiO_2 particles becomes, the larger the value of resistance becomes.

Experiment 2: The relationship between the absorptivity rate of light and voltage.

We contemplated that the voltage is independent of the area of TiO_2 paste because the type of components of the battery determines the battery's voltage. As the area of TiO_2 paste increases, the number of TiO_2 particles increases as well. Also, as the TiO_2 paste area increases, more coloring matter clings to the TiO_2 particles. Thus, we contemplated that the electrical power is in proportional to the surface area.

Experiment 3: The relationships between illuminance and the electric current voltage.

We considered that voltage is independent of illuminance because it is determined by the kind of battery components. And we considered electric current is in proportion to illuminance because the number of the coloring matter which receives light and makes electrons exciting increases due to rise of illuminance. Due to illuminance, voltage becomes constant and the electric current increases, so electrical power is in proportion to illuminance.

5. Conclusion

In summary, we think the three following conditions are the best for dye sensitized cells:

1) The absorptivity of light is between 40％ and 60％
2) Using proper components which render the voltage larger
3) The area of TiO_2 is large

6. References

1) Peccell Co., Ltd. "the mechanics of Dye Sensitized Solar Cells / Peccell technologies". http://www.peccell.com/shikiso.html, (reference 2020-11-16)
2) The development of Dye Sensitized Solar Cells – the application of plastic parts and reduction of the amount of Platinum

7. Key words

TiO_2 absorptivity of light voltage electric power dye-sensitized solar cell