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Models & Inventions

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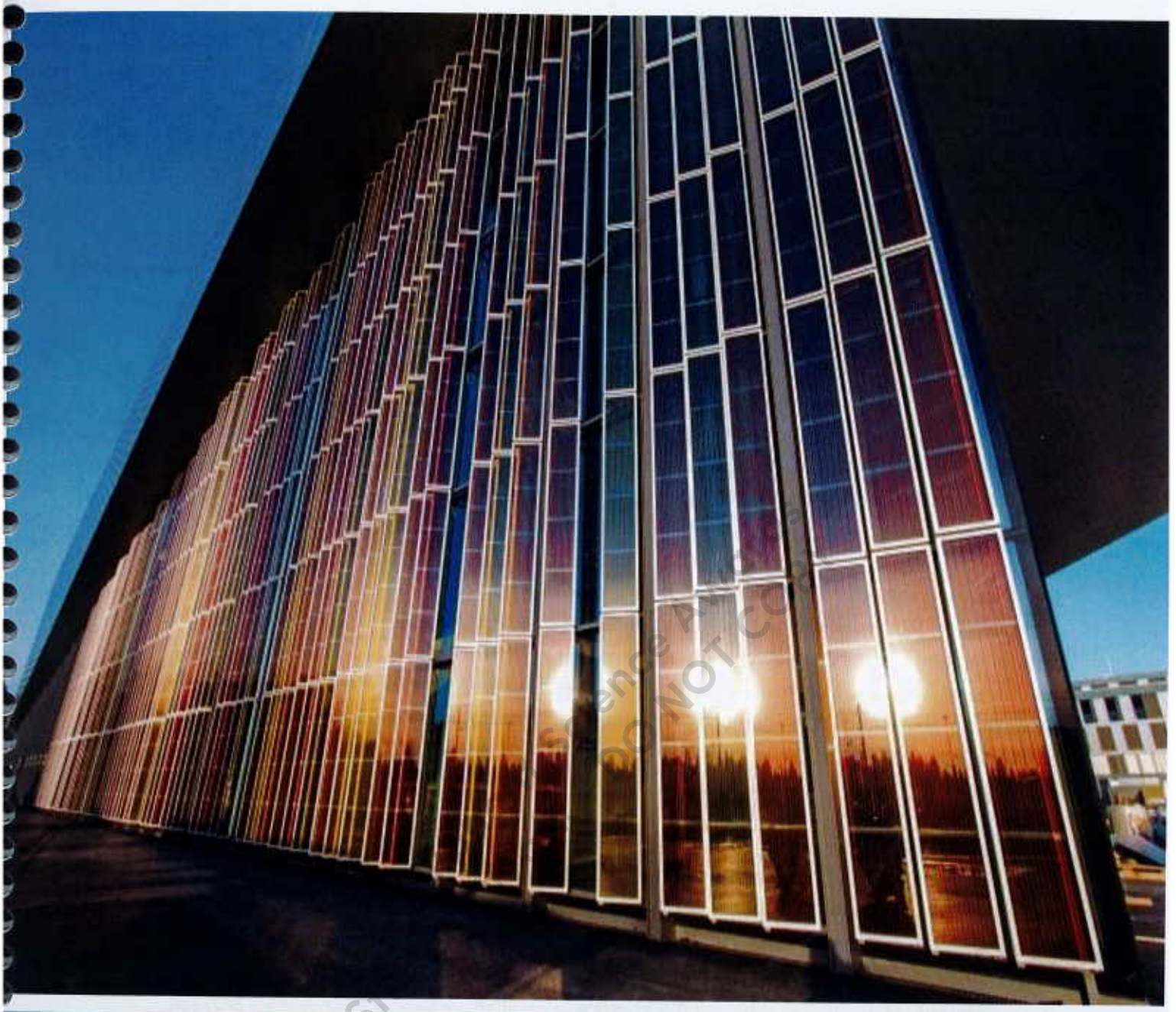


Dye-Sensitized Solar Cell (DSSCs) and Practical Application.

0485 - 001

Research Motivation

Solar energy is the cleanest, most economical, and most accessible energy in the world. The amount of energy that sunlight hits the ground is about 3×10^{24} Joules per year, which is equivalent to 10,000 times of the energy consumed every year. Solar Photovoltaic is a kind of renewable energy power generation equipment that can directly convert light energy to electrical energy. Its solar photovoltaic module is designed to be used outdoors for a long time, and the equipment life is about 20 to 25 years. However, even if the service life is long, there will still be the problem of scrapping the service life of the equipment. The waste and recycling of solar modules has become a topic of great concern in the world. How to effectively recycle and dispose of the waste solar modules and avoid the environmental damage caused by a large number of waste solar cells has been a subject of considerable attention in recent years.

Dye Sensitized solar cell (DSSC) is a disruptive technology that can be used to produce electricity in a wide range of light conditions, indoors and outdoors enabling the user to convert both artificial and natural light into energy to power a broad range of electronic devices. More importantly, almost all materials of DSSCs are non-toxic substances, and almost accessories can be reused. Compared with other silicon solar cells, DSSC are more environmentally friendly, lower performance of light, and cost-effective.

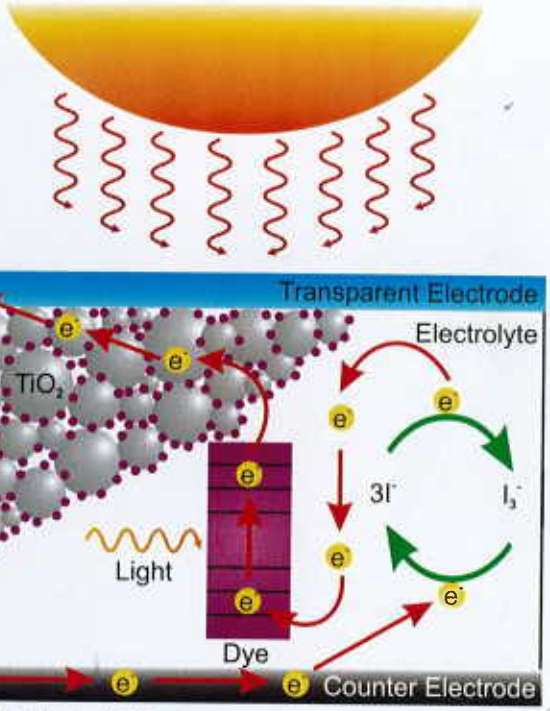
What is a DSSC?

The dye-sensitized solar cell is composed of a porous layer of titanium dioxide nanoparticles, covered with a molecular dye that absorbs sunlight, like the chlorophyll in green leaves. This technology was first published by "Grätzel cell" in 1991, electric energy can used directly or stored by a storage device. It has different colours due to different dyes, so it is also called a Rainbow Photovoltaic (PV) cell.

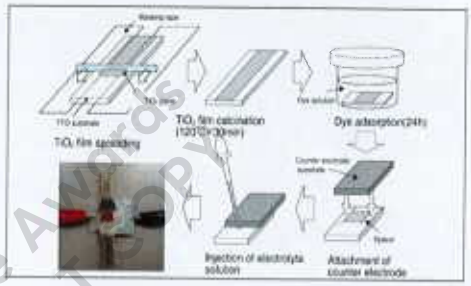
Mechanism of DSSCs

1. $S + light \longrightarrow S^*$
2. $S^* \xrightarrow{TiO_2} S^+ + e^-$
3. $S^+ + e^- \longrightarrow S$
4. $I_3 + 2e^- \longrightarrow 3I^-$

1. **Dye becomes Excited from the ground state (S) to the excited state (S*) by sunlight or indoor light.**
2. **Dye injects an electron rapidly to the TiO_2* (the conduction band), dye is oxidized in this process.**
3. **Electrons are transported through the semiconducting TiO_2, move through the load, and eventually reach the counter electrode.**
4. **The oxidized redox mediator, I_3, diffuses toward the counter electrode and then it is reduced to I^- ions.**



https://en.wikipedia.org/wiki/Dye-sensitized_solar_cell#/media/File:Dye_Sensitized_Solar_Cell_Scheme.png

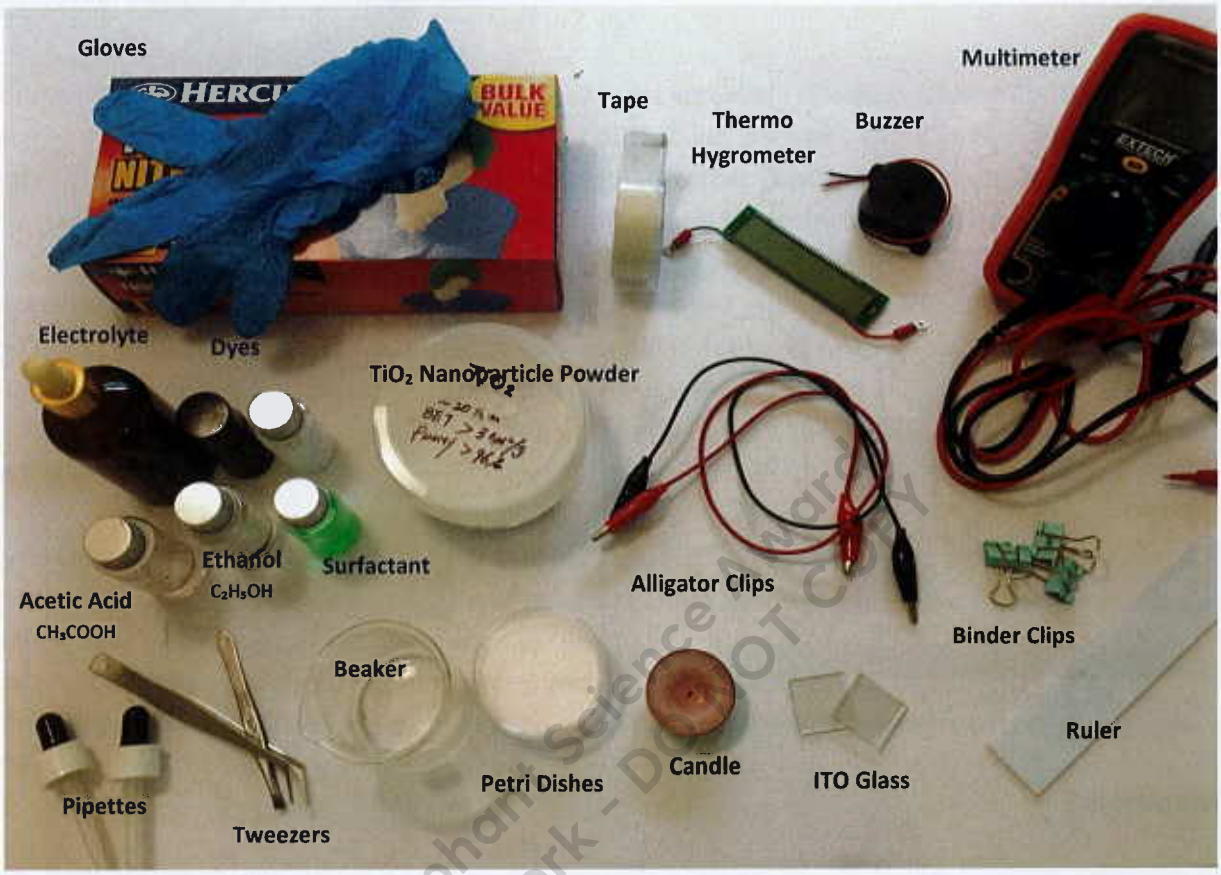


Materials

In my entry model, I would like to create a classroom with DSSCs, which can drive the clock, the hygrometer, and the ringing of the class bell. If it goes well, I will try to create my own flexible and bendable solar cell. To start my project, I need to create a DSSC sample and test it successfully before I can go on to my next step of model creation.

Materials and Equipment

Equipment		Chemical Used	Biologicals
1 × Electronic Scale	1 × Lighter	1 × 50mL of 100% Ethanol (C_2H_5OH)	Blackberry
1 × Heating Plate or Oven	1 × Candle	1 × 10g of TiO_2 Nanoparticle Powder	
1 × Hot Glue Gun	2 × 100mL Beakers	1 × 5mL Acetic Acid (CH_3COOH)	
1 × Safety Goggles	10 × Cotton Swabs	1 × 5mL of Triton X-100 surfactant (Dish Washing Liquid)	
1 × Measuring Cylinder 100mL	10 × Binder Clips	1 × 10mL of Electrolytes (KI_3) Potassium Triiodide	
2 × Tweezers	6 × Alligator Clips	40 × ITO Glass (Indium Tin Oxide)	
1 × Long Stick, Ruler or Slide	3 × Plastic Pipettes		
5 × pair of Disposable Gloves	1 × Box of Tissues		
3 × 10 mL Plastic Bottles			
3 × Plastic Petri Dishes			



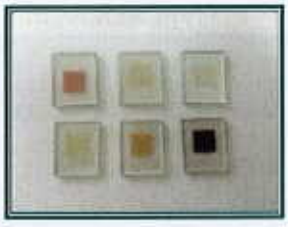
Methods

1. Determine conductive side.

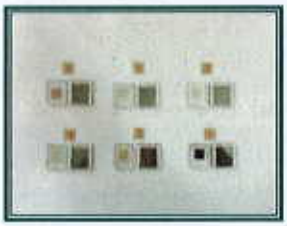
2. Preparing the TiO_2 paste.

3. Preparing the dyes.

4. Preparing the anode.

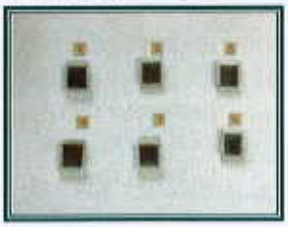


5. Preparing the cathode.



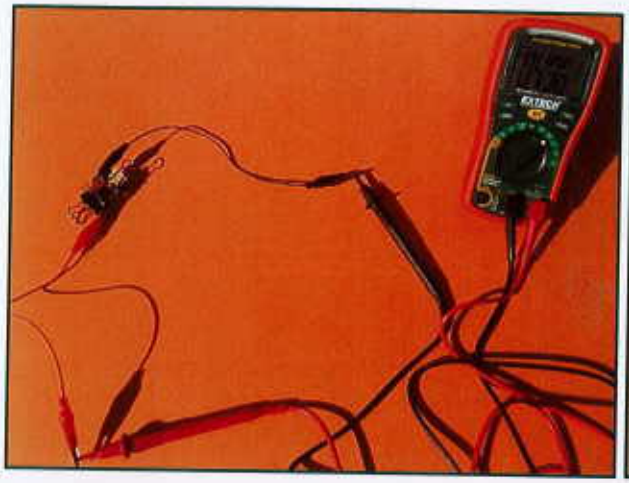
6. Adding the electrolyte.

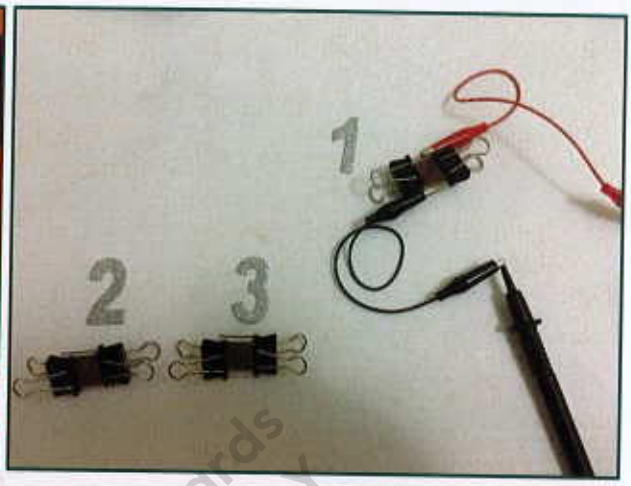
7. Combining the parts.

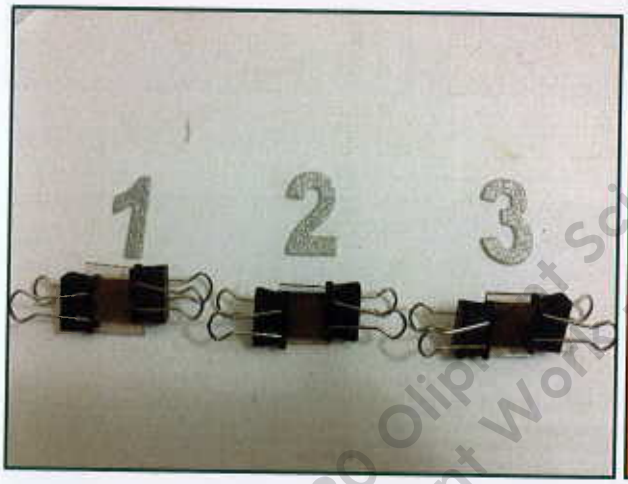


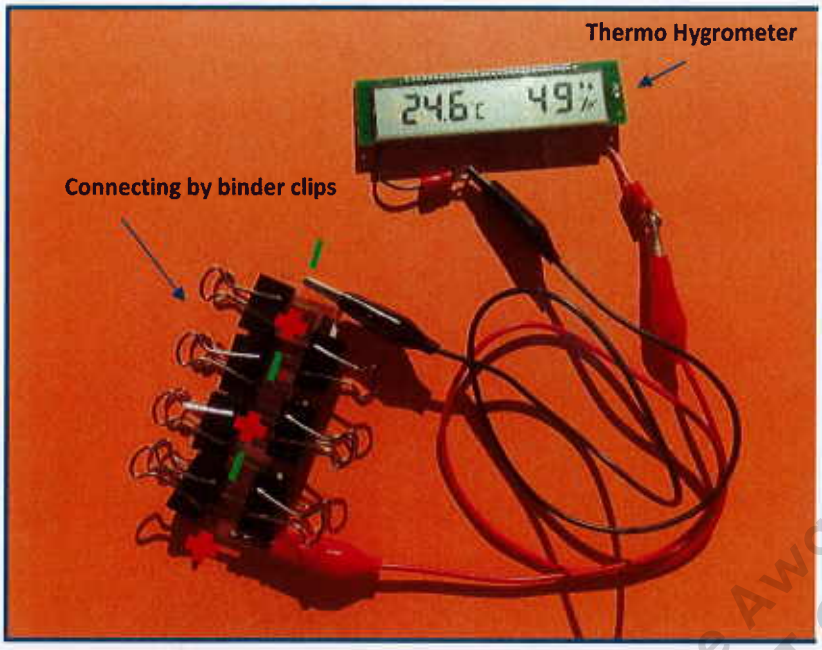
8. Ready for testing.

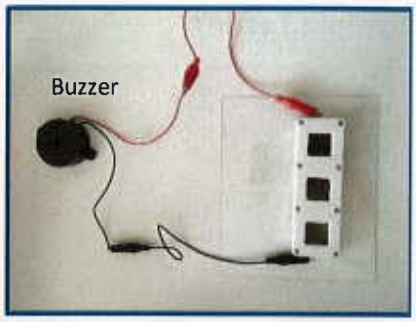
Sample Testing

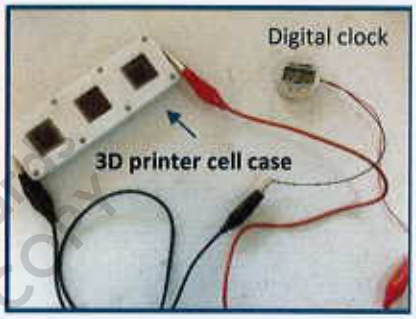




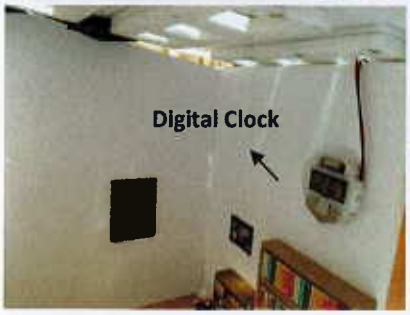


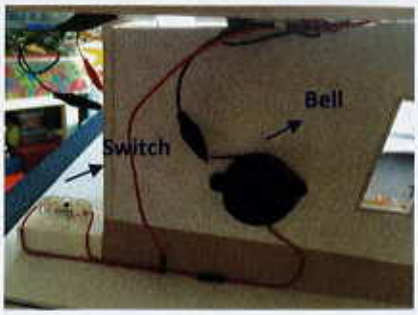






DSSC Smart School

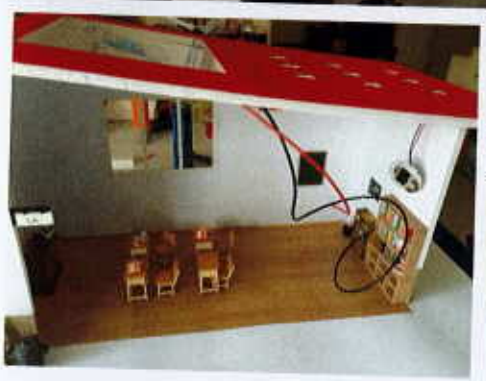


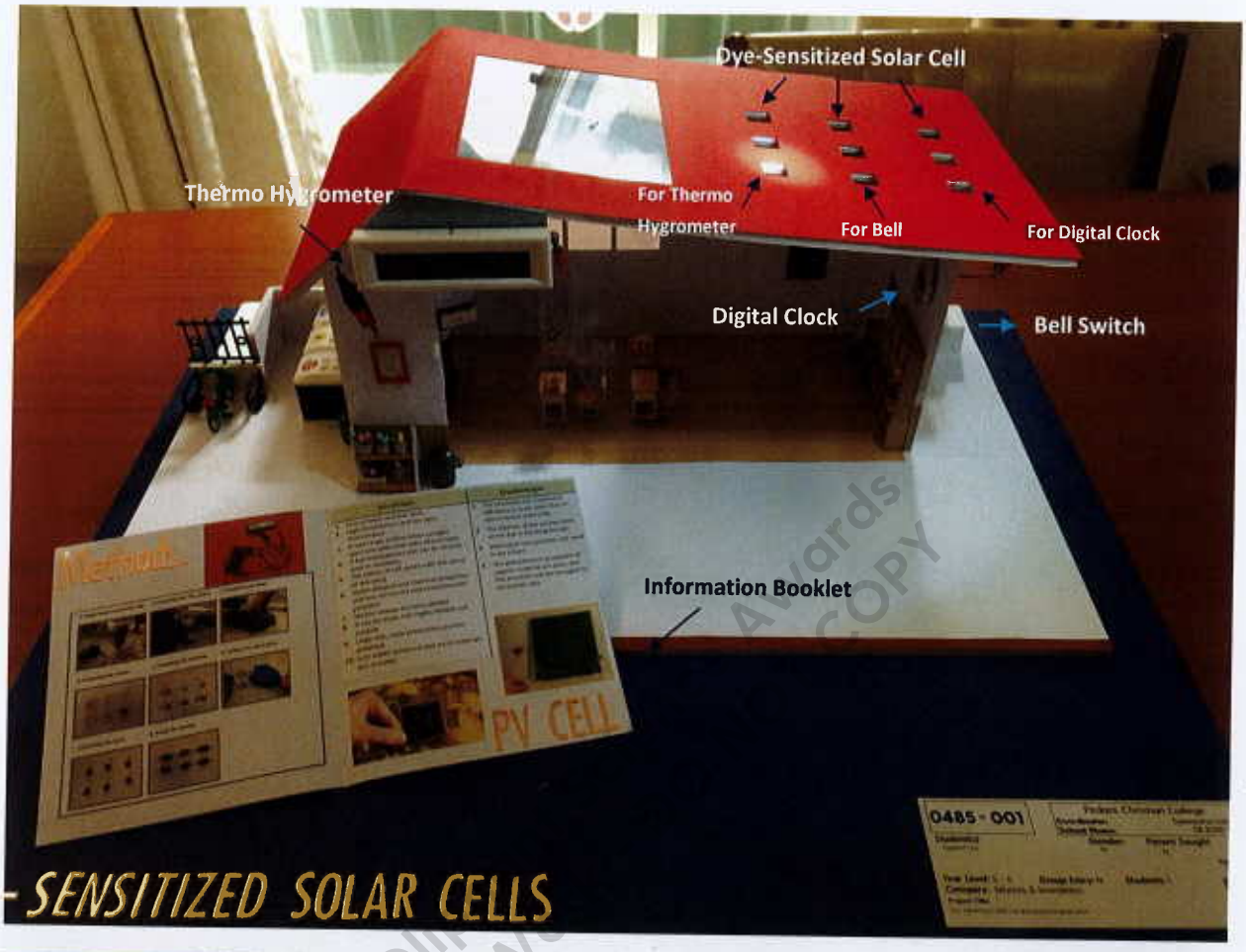


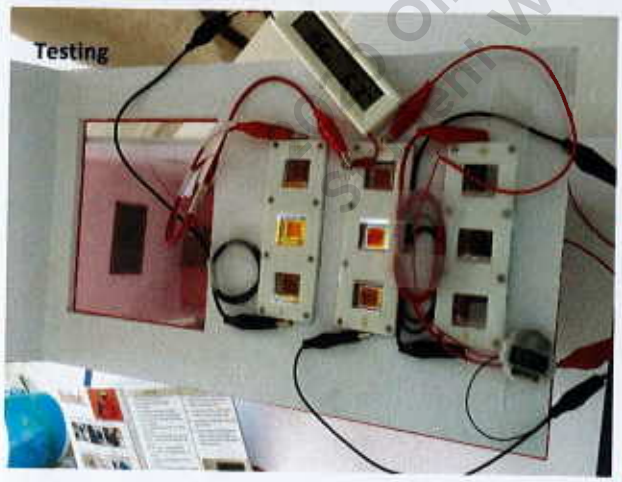
First Sample Model Creation:

Second Model Creation:

Installation of DSSCs, wires and electronic parts.

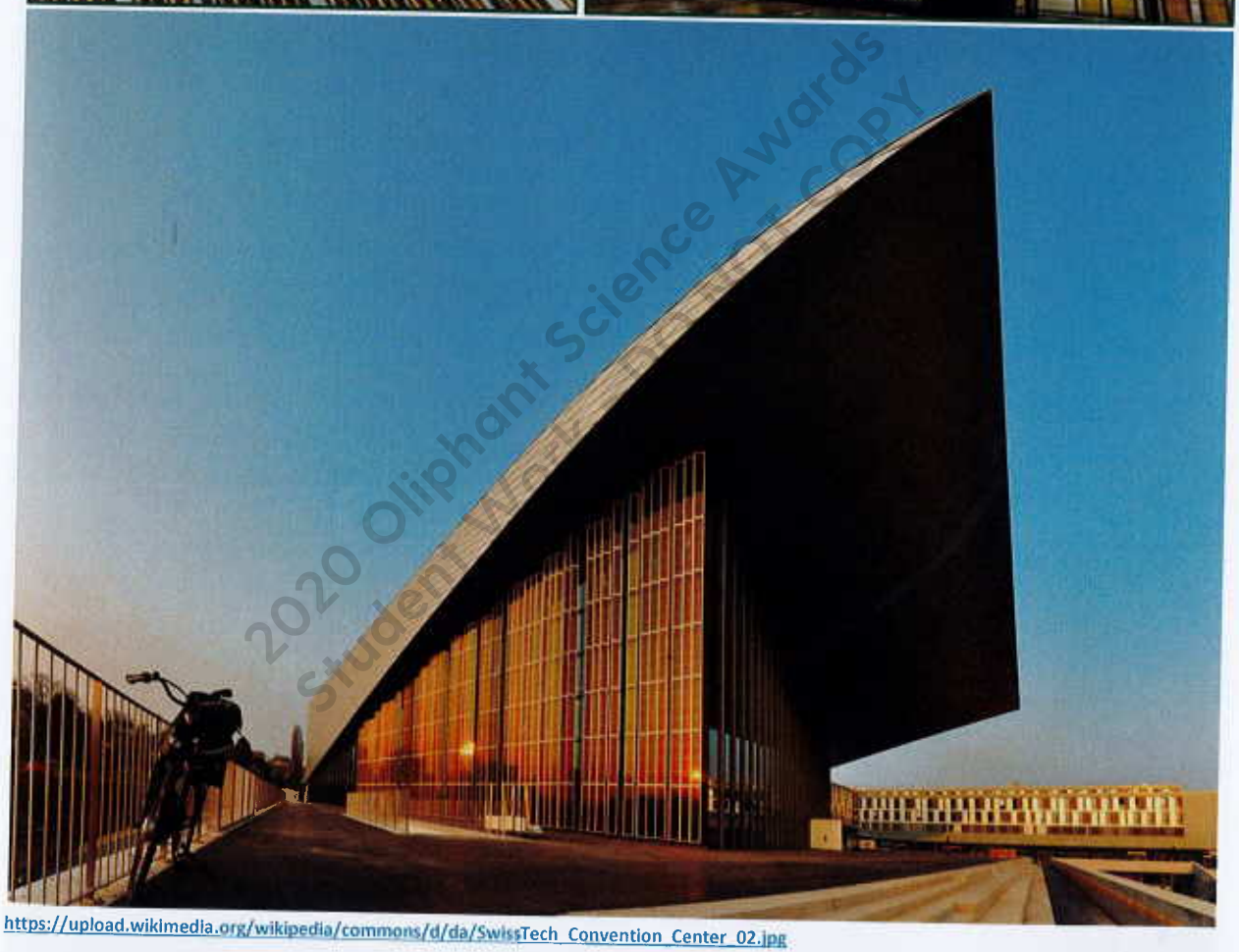






After testing, my Smart DSSC School project can run normally and successfully, , the DSSCs I installed on the top of the roof can drive a small digital clock, a thermo hygrometer, and a bell, each set of DSSCs can generate around 1.5~1.8V under sunlight. I installed a switch in the bell in case of a continuous ringing. And then I could start creating my own flexible DSSCs.

Examples of DSSCs are currently in use.

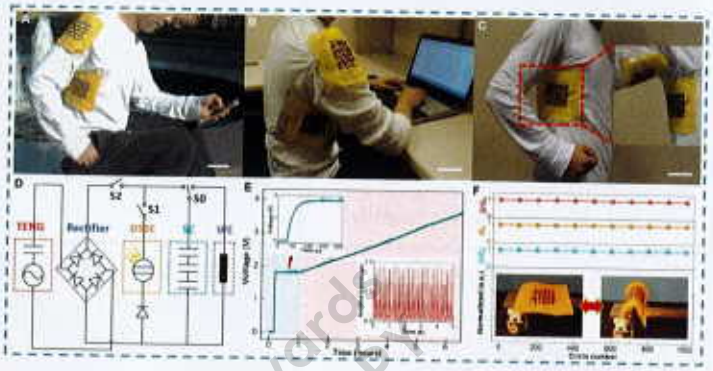


https://upload.wikimedia.org/wikipedia/commons/d/da/SwissTech_Convention_Center_02.jpg

SwissTech Convention Center *in Switzerland opened in 2014, housing a 3,000-seat modular amphitheater. 300 m² of dye photovoltaic cells are integrated into the western façade of the building, generating 2,000 kilowatt hours of electricity annually and thus reduce the costing for using cooling energy. The translucent panels make use of an invention by Michael Grätzel, a researcher at EPFL, a research institute and university in Lausanne, Switzerland, the specializes in nature science and engineering.*

Flexible, Bendable and Wearable DSSCs

It is the dream of scientists to realize wearable solar clothes and 3C devices, DSSC are considered to be the most potential products due to its high flexibility. I try to use simple materials to create the bendable DSSC. Because ITO glass can't bend, I use aluminum foil and copper sheet available at hand to replace conductive glass, so that the bendable plastic can conduct electricity.



How to create the flexible DSSC and What do we need?

Methods of Creating the Flexible DSSC.

1. Cut the aluminum foil and copper sheet as shown above. Prepare the dyed TiO_2 film and carbon coating.

2. Place a piece of dust free paper on the top of TiO_2 film.

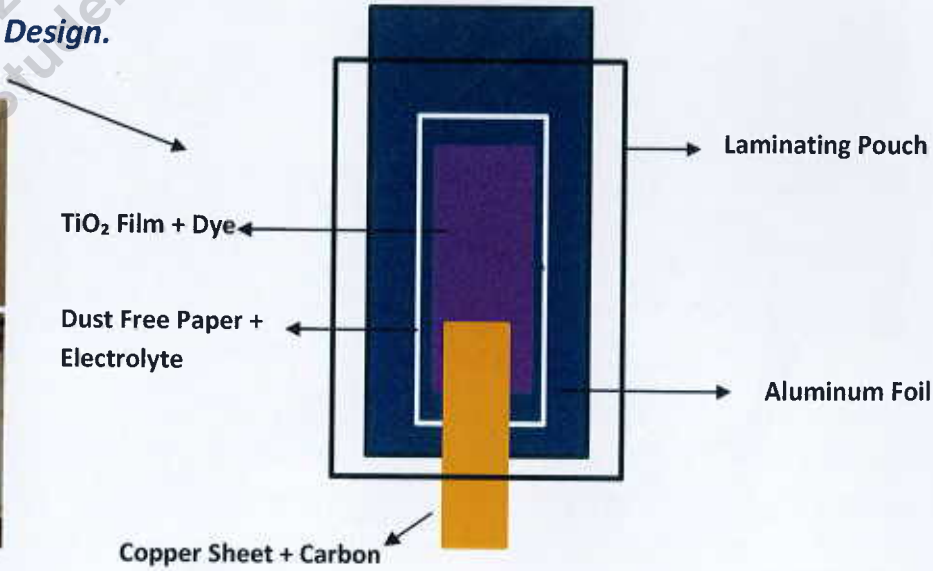
3. Drop the electrolyte on the dust free paper.

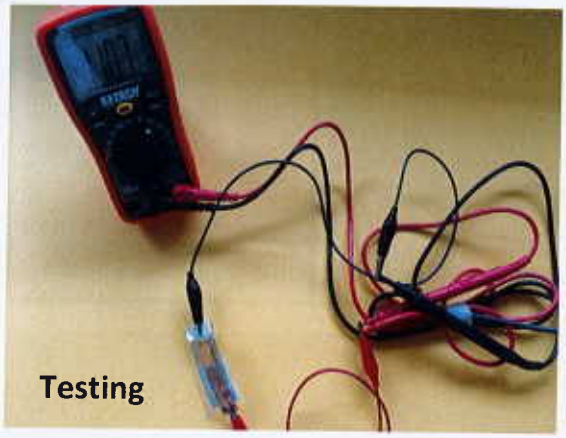
4. Place the copper sheet on the top of the dust free paper and place the cell inside the laminating pouches.

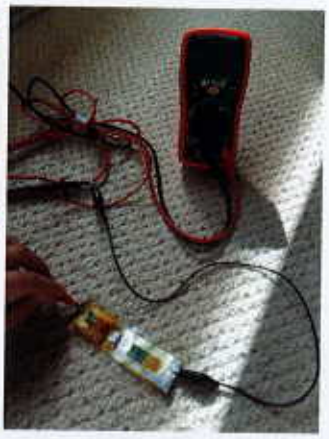
5. Use the hair straightener to heat the laminating pouches and pack the DSSC inside.

6. Fold the positive electrode copper sheet and negative aluminum foil, and the packaging is completed.

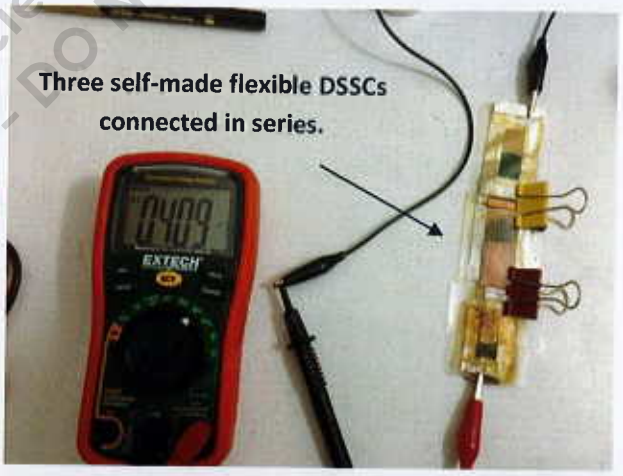
My Own Flexible DSSC Design.







I've created several flexible DSSCs, but the generated voltage is only about 0.1~0.3 volts lower than the cells using ITO conductive glass. I connected several self-made flexible DSSCs in series, the voltage generated was about 0.4~0.7 volts, which was not enough to drive small electronic devices, such as digital clock. After connecting multiple cells, the internal resistance increased, and the voltage tended to be unstable.



Power Generated: 0.195 V
Created on 13 July 2020

Power Generated: 0.263 V
Created on 30th July 2020

Power Generated: 0.150 V
Created on 1st August 2020

Power Generated: 0.397 V
Created on 10th August 2020

Summary

In the last two decades, dye-sensitized Solar Cell (DSSCs) have attracted more attention as an efficient alternative to economical photovoltaic devices, and the highest efficiency record has increase from 7% to 14%. How to effectively increase the photovoltaic conversion rate and the application of other related products will be the main topic of this decade, highly flexible wearable DSSCs is the most important subject among them.

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