Hong Kong Student Science Project Competition 2022

Template of Extended Abstract (Investigation)

(Word Limit: 1,000 words, Pages: 2 pages only)

Team Number: SBBC249

Project Title: Dye Sensitised Solar Cells Alternatives with the use of Natural Plant Dye Extracts

Project Type: Investigation

To our best knowledge and after thorough literature research, as at 05/07/2022 , there are / ~~are no~~* similar works. If there are, the reference links are as below:

Recent Advances in anthocyanin dyes extracted from plants for dye sensitized solar cell By Negese Yazie Amogne, Delele Worku Ayele, Yeshitila Asteraye Tsigie

Dye-Sensitized Solar Cells: Fundamentals and Current Status By Khushboo Sharma, Vinay Sharma, S.S. Sharma

Improving the Performance of Dye-Sensitized Solar Cells By Gerrit Boschloo

Dye Sensitized Solar Cells By Di Wei Where I work Maria Fernanda Cerda From Nature Vol.596 on 12th August 2021

Do you know Dye sensitized solar cells? From YouTube, GREEN TECHNOLOGY LIFE

Dye Sensitized Solar Cell Demonstration By ESF Productions in 2009 In association with the Department of Chemistry, State University of New York Adopted from YouTube

The enhancement our project has made for the existing related products or research is summarized as below:

The group have successfully obtained a constant value of voltage with our proposed prototype of DSSCs with the use of different natural dyes under sunlight and artificial lighting.

***Please delete if not applicable. HKSSPC values the originality of works. Students must conduct literature research thoroughly to ensure that their works are unique, and to list relevant reference materials to complement the research or invention.**

I. Background

Renewable energy has shown its growth in daily usage and will continue expand. However, it is known that different kinds of renewable energy have their respective limitations. To maintain a stable and reliable renewable energy supply, other sources of raw materials can also be used in energy production. In response to the rapid development of clean, renewable energy, the group will investigate the practical use of Dye Sensitised Solar Cells (DSSCs) and natural dye photosensitizers as alternate materials, along with the possibility of utilizing solar power with our newly revamped DSSCs to increase the efficiency of generating electricity. Our proposed DSSCs are customized where it can be used on the exterior surface of high-rise buildings such as the IFC and ICC. Due to the flexibility of DSSCs, it can be installed at where energy can be generated but current solar panels cannot. We therefore wish to provide an extensive and effective renewable energy solution for Hong Kong.

II. Objectives

In response to the rapid development of clean, renewable energy, the group will investigate the practical use of Dye Sensitised Solar Cells (DSSCs) and natural dye photosensitizers as alternate materials, along with the possibility of utilizing solar power with our newly revamped DSSCs to increase the efficiency of generating electricity by using different types of natural dye extracts.

III. Hypothesis

To investigate the photon harvesting ability of natural Dye Sensitised Solar Cells. The group will experiment the photon absorption abilities of the aforementioned dyes and investigates their most effective physical and chemical conditions by blending with other substances.

IV. Methodology

Materials and apparatus:

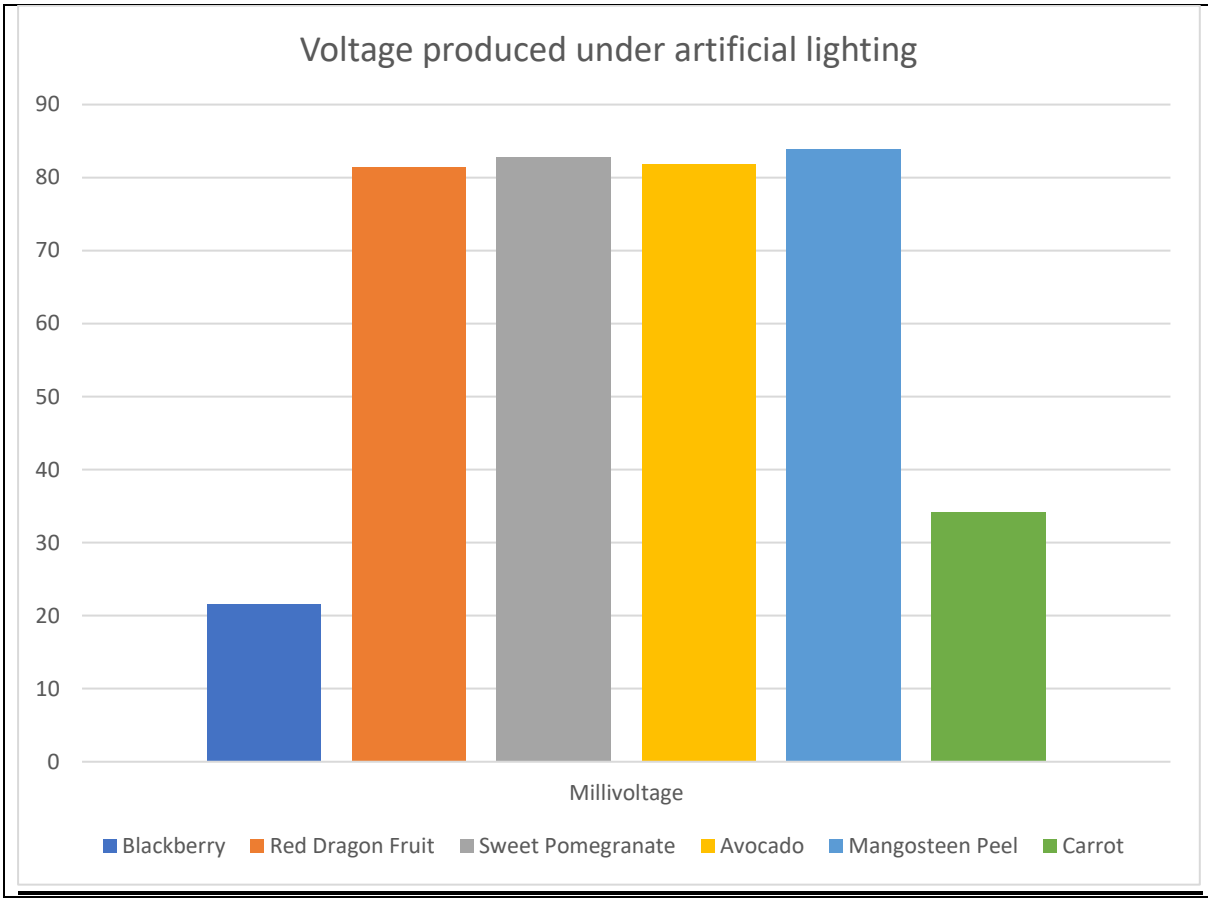
Nano-porous Titanium (IV) Oxide Powder
0.1 M Nitric acid
2cm x 2cm Semiconductive Glass (FTO)
Pencil
File Clips
Tape
Alligator clips
Voltmeter
Artificial lighting tube
Natural Dye Solutions

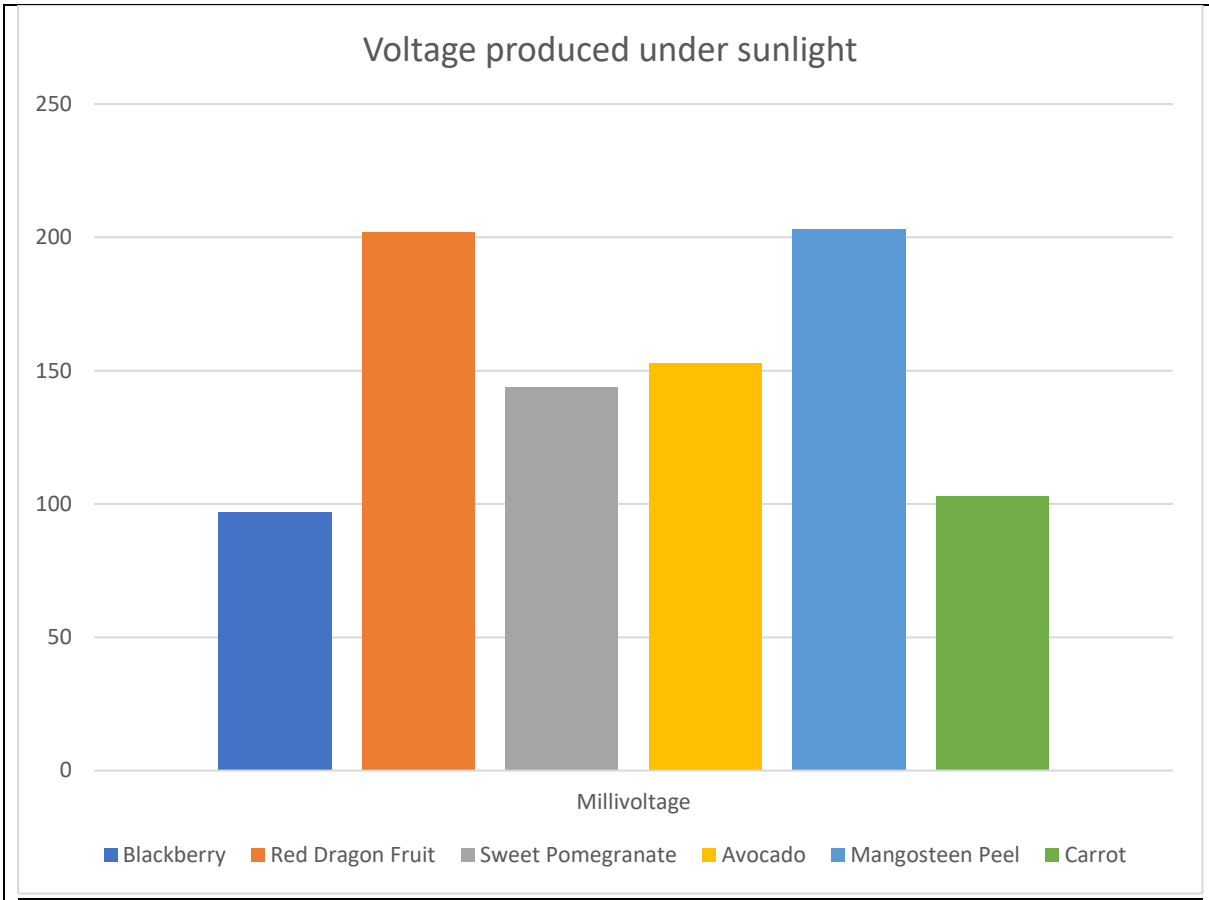
Experiment Procedures:

1. Measure 5.91 grams of Titanium (IV) Oxide powder with an electronic balance
2. Mix the Titanium (IV) Oxide powder with 8.44 cm3 of 0.1 M Nitric Acid in standard condition to form a paste
3. Use pencils to colour opposite sides of 2 pieces of FTO glass as graphite is a good conductor of electricity
4. Apply tape on sides of a piece of FTO glass to prevent spilling of paste
5. Deposit the TiO2 paste evenly on the conductive glass with a glass rod
6. Allow the paste to dry
7. Apply one drop of dye solution using a dropper and allow the TiO2 to absorb, the colour of TiO2 will change from white to the dye's colour, then remove excess amount of solution using a dropper
8. Bind the two conducive glasses together except the area with graphite and hold them with 2 file clips
9. Place the alligator clips on the area with graphite to measure the reading of voltmeter
10. Place the cell under a artificial lighting tube for 3 minutes for initiation, then record the reading of voltmeter in 30 seconds interval
11. Repeat step 10 under sunlight condition
12. Repeat step 1 to 11 with different dye solutions

The energy generate will be transfer to the circuit and reach the secondary chemical cells for storage through metal wires instead of Alligator Clips. While a thin layer of plastic (Perspex) and an air gap will be preserved for heat absorption and insulation. Air and plastic are an outstanding heat insulator, which it prevents the cell from degradation due to high temperatures under intense sunlight.

V. Results





Errors and improvements

During the experiment, several concerns were raised regarding the errors of the experiment of inaccurate results.

1. Poor conduction of the cell, can be improved by using a thinner layer of paste with a higher concentrated area of graphite
2. Insufficient amount of dye solution, can be improved by preparing a larger amount of dye solution e.g., 10 cm3 then add on TiO2 paste with dropper
3. Cell contains impurities, can be improved by washing the paste with deionized water and filter the dye solution with filter paper and filter funnel
4. Light intensity due to adverse weather conditions, can be improved by measuring the light intensity using a photometer, then factor in the effect into the results

Applications

This section will focus on the possible real-life applications of the Natural Dye Sensitised Solar Cells after the solution with the best performance-cost ratio is discovered. In this development, cost reduction will be our main priority to ensure competitiveness.

Solar Panels:

The cells are manufactured into large scale solar panels which can be applied on windows or exterior walls of high-rise buildings. However, a few retrofits are made to suit the intensive working environment.

The panels are casted in window frames which holds the panel in its position, a thin Perspex layer is

added in the outermost layer of the cell and an air gap is enclosed between the Perspex and working electrode in order to prevent cell degradation due to high temperatures.

Thin-Film Cells:
The cells will be fabricated into thin-film solar cells, which greatly reduces the amount of materials required and hence, reduces the units cost.

Energy Storage:
All energy shall be transferred to secondary chemical cells for external storage, as the cell itself does not provide any means of electrical storages. Or otherwise, the electrical energy shall be directly supplied to the electrical application, any excessive energy will be consumed by resistors if not already used.

Experiment of application:
Cells will be tested of their abilities to charge secondary cells, in which, their voltage, current and speed will be recorded.
Large solar panels will be accessed in powering light bulbs, which ensures its adequate performance in low demand daily usage.
All cells will undergo long-term testing to ensure their effectiveness in running continuously.

It is suggested that further design is needed for the application of Solar Panels.

VI. Conclusion

As mangosteen peel and red dragon fruit are two different types of natural dye extract which contains anthocyanin, with both dye solutions able to produce a stable voltage (above 200mV), and carrots which contains carotenoid also being able to produce a stable voltage (above 100mV), the hypothesis is proved and meets the objective. We will now aim to increase the efficiency and the design of the cell.

☐ **Our project is developed based on our school's previous project and the enhancement is as below:**