Electricity from Fluorescent Protein Solar Cells – Ronald Vuong and Ian Rodgers

Background: The project for developing Fluorescent Protein (FP) Dye-Sensitized Solar Cells stems from a legacy of projects previously submitted from Centennial C.V.I. Two projects in the past involved the use and construction of Dye-Sensitized Solar Cells, and we wanted to further their findings and ideas by incorporating fluorescent proteins. This project addresses the world's need for renewable energy. Busy, downtown districts have very little space for anybody to use a solar panel, and if any are purchased and installed, the tall buildings block out much of the sunlight required to operate the solar panel. Michael Gratzel has developed an alternative solar cell called the dye-sensitized solar cell. This solar cell is very low-cost, since it has cheaper components. The main characteristic in a dye-sensitized solar cell is that a dye is used to absorb different wavelengths of light. The dyes come from different sources, but since it is the pigment of the dye that is important, there are many sources dyes come from that are high in abundance in nature. One significant drawback to both the dye-sensitized solar cells and commercial solar panels is that they only absorb light in the visible spectrum. The *Aequorea victoria* jellyfish harbors a specific protein called Green Fluorescent Protein (GFP) that fluoresces after absorbing UV radiation. This fluorescence reveals to us that this protein does transform energy and re-emits it after absorbing energy from UV radiation.

Used in conjunction with the dye-sensitized solar cell, we will be able to harness both the visible and UV light emissions from the sun, and increase the overall efficiency of solar cells. If an efficient design is created, more colours of fluorescing proteins will be able to be incorporated, and thus further increase the efficiency of the dye-sensitized solar cell by expanding the range of spectra that can be absorbed by the cell and transformed into electricity. Already, there are designs of dye-sensitized solar cells that include many colours of dyes together in one array.

Purpose and Hypothesis: Our project was conducted to test the effect of Fluorescent Proteins on the efficiency of Dye-Sensitized Solar Cells. The addition of several types of Fluorescent Proteins to our solar cells should expand the absorption spectra of the cell and therefore more electricity should be produced from the solar cell when exposed to visible and UV light.

Materials:

Luri-Bertani/Arabinose/Ampicillin Agar Plates

GFP, BFP, pgloGFP plasmids

Centrifuge

TE buffer

BioRad purification column

BioRad binding buffer

Nanocrystalline titanium dioxide

5% Acetic acid

Sodium dodecyl sulfate surfactant

Indium Tin Oxide conductive plates

Red cabbage juice

Candle

Multimeter

Triiodide elecrolyte

Procedure: We began by performing transformations to express the fluorescent proteins in colonies of *E. coli* bacteria. The transformed colonies were isolated onto LB plates. We then inoculated the transformed bacteria into liquid media. This liquid media was spun down in a centrifuge, combined with TE buffer then lysed using the enzyme lysozyme. The lysed bacteria were then sent through the FP purification column that removed the non-fluorescent proteins from the samples. The end result of the process was purified proteins suspended in a buffer solution. We then went on to making our cells. To create our dye-sensitized solar cells (DSSCs) we first mixed the titanium dioxide powder with 5% acetic acid under a fume hood. We then added the surfactant (sodium dodecyl sulfate), resulting in a paste with the consistency of paint. This paste was applied uniformly to the conductive plates. For a control cell without any FPs, the coated plate would then be placed face down in cabbage juice (anthocyanins). Cells incorporating the fluorescent proteins (GFP, BFP, pGloGFP) would be placed faced down in a mixture of both the protein and the cabbage juice. This stained plate would then be joined to another carbon coated plate. The electrolyte is then put between the two plates, diffusing through capillary action. The cells were then tested using the multimeter.

Results and Observations: We were able to test stock DSSCs against cells which used GFP, BFP and pGloGFP combined with the stain, as well as cells using only GFP and pGloGFP. The cells were tested using a 150-10000 Ohm variable resistor and a multimeter. Current readings through different magnitudes of resistance showed us that cells which integrated FPs into the design produced more current. The cells however were deteriorating quickly over the course of a few hours after their construction.

Conclusions: The conclusion we can gather from our data is that the fluorescent proteins we incorporated into the DSSCs were able to improve the absorption spectrum of the cells. This can be seen through the increased power readings. Fluorescent proteins clearly have the potential to improve the standard Dye-Sensitized solar cell. We hope to see them improved and stabilized, so that they might offer a better alternative to the current Silicon based cells by improving the efficiency of Dye-Sensitized Solar Cells.

Acknowledgements: We would like to recognize Mr. Gajic and Ms. Brown for their help in ensuring we had access to the materials and skills needed to complete this research, and for the amazing support they provided all throughout the entire process. Through this experience, we were able to learn how different types of FPs affected the efficiency of DSSCs, as well as many skills useful in biotechnology at large. We would also like to recognize Yuanxin Wang for her help in designing the poster and her support throughout the duration of our project.

References

Gratzel, Michael. **Solar Energy Conversion by Dye-Sensitized Photovoltaic Cells**. *Laboratory for Photonics and Interfaces, Swiss Federal Institute of Technology, CH-1015 Lausanne, Switzerland.* May 24, 2005

Wan, Haiying. **Dye Sensitized Solar Cells**. *University of Alabama Department of Chemistry.*

Prendergast F, Mann K (1978). **Chemical and physical properties of aequorin and the green fluorescent protein isolated from Aequorea forskålea**.

Knight, Helen. **Green machine: Squeezing solar juice from jellyfish**. January 2010