The Use of Fluorescent Dye on Efficiency of Photovoltaic Cells

George N. Theodosopoulos and Markella Tsalikis

Abstract— **Polycrystalline silicon solar cells cannot effectively convert all wavelengths of light into usable electricity and as a result, this excess energy is wasted through thermalization and decreases the overall efficiency of a cell. To study the wavelength conversion and thermalization processes, three fluorescent dyes were applied to crystalline solar cells. Through the analysis of the power output and temperature of the solar cells, it was found that fluorescent dyes can be utilized to increase the efficiency of the solar cell through down conversion.**

I. Introduction

The sunlight that hits the earth is enough to entirely power the world's energy needs. [1] This solar energy, however, cannot be used, as most commercial solar cells have efficiencies of less than 20%. [2] The wavelengths converted by solar cells is restricted by the bandgap; only wavelengths between 300 and 700 nm can be absorbed by silicon solar cells. [3] However, wavelengths under 400 nm are often wasted as heat within the cell.

Fluorescent dyes can be used for down converting light as they have the ability to convert one high-energy photon into two or more low energy photons. Electrons are excited by the photons and when they fall back down, they release two photons that have lower energy. [4] By utilizing fluorescent dyes, wavelengths under 400 nm can be converted tp above 600 nm, which the silicon cells can use mefficiently.

II. Methodology

Three different fluorescent dyes were used for the down conversion process: Coumarin 6, Coumarin 153, and Coumarin 102 (Sigma Aldrich). Each dye was prepared with a polymer, a paint base, to make 2%, 6%, and 8% concentration solutions, which were applied to the surface of the cells. The untreated cells acted as the control. Three 90 Watt LED lights were used: red, blue, and white. The red and blue lights were used to test more specific wavelength ranges and the white covered the whole spectrum. Each light was tested on the 8 different groups of solar cells with a total of 150 trials. IBM SPSS was used to calculate descriptive statistics.

III. Results and Discussion

It was hypothesized that the fluorescent dyes would increase the overall power output. This was supported in that all of the groups produced higher power outputs than the control. Similar to Strumpel et al's results, it was found that the application of fluorescent dyes allows for absorption of light that was previously not utilized. [5] Coumarin 6 at 8%, however, actually yielded lower power than the untreated cells. This may be due to fluorescent quenching.

All cells produced the most power under red light. Red light includes wavelengths between 620 and 750 nm, which most efficiently absorbed and converted into energy.

Overall, Coumarin 102 outperformed the other dyes. Coumarin 102 at 2% produced the highest power outputs under all three lights. The other Coumarin 102 concentrations produced the second and third highest under the same conditions. Coumarin 102 down converts from 390 nm to 461-513 nm. This suggests that these are the most optimal wavelengths that are absorbed by the solar cell.

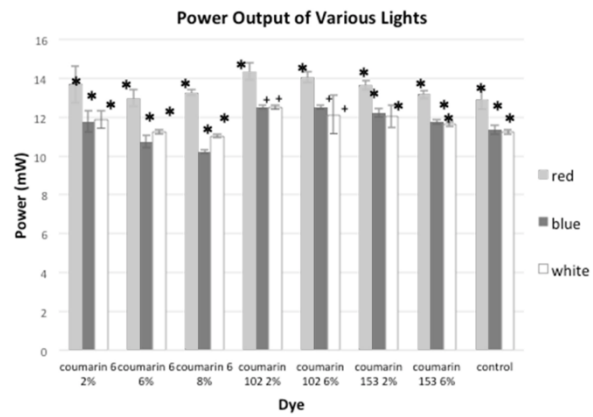

Figure 1: This graph shows the power output of each dye under each light.

The only group that had a significantly higher temperature change compared to the untreated cells was Coumarin 102 at 6%. Coumarin 102 produced more power over time, however, this is irregular because solar cells generally decrease in efficiency at higher temperatures. [6] The heat increase may not have been due to internal thermalization, but rather an external source, like the light itself.

IV. Future Studies

A wider range of dyes along with more specific wavelengths of light, which may be produced by using a monochromator, can be studied to see a more specific range of wavelengths that the dyes are able to absorb and convert.

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Manhasset Secondary School, Manhasset, NY 11030 USA

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