CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)
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Project Number
S1712

Project Title
A Novel Study on the Improvement of Electronic Transport Characteristics in a Dye-Sensitized Solar Cell

Abstract

Objectives/Goals
The objective is studying the effects of sealing the device to prevent degradation, using different natural dyes, varying the concentrations of the Anthocyanin dye, annealing the front contacts of the devices at different temperatures, adding a mirror underneath the device to allow unabsorbed light to reflect back for a second pass, and understanding the current-limiting mechanism via analysis of IV measurements.

Methods/Materials
I built a 1-Sun, warm white LED light source for efficiency measurements. IV characteristics were measured with a Syscomp curve tracer. 25 DSSCs were fabricated with an Arbor Scientific Dye Sensitized Refill Kit, and with 5mM H_2PtCl_6 as the Platinum catalyst on the back contacts. Most of the DSSCs were dyed with blackberries. Some DSSCs (a) were side-sealed with epoxy to study the effects on degradation, (b) were dyed with various concentrations of Anthocyanin (from blackberries) dissolved in methanol, (c) had the Titanium Dioxide (TiO_2) annealed at different temperatures, (d) had a mirror mounted on the back contacts to allow unabsorbed light to reflect back for a second pass. Finally, solar power conversion efficiencies were measured and IV curves were analyzed with Excel.

Results
Sealing the devices significantly prolonged the life of the devices. Out of the natural dyes, Anthocyanin dye had the highest efficiency. Increasing the concentration of the Anthocyanin dye also led to higher efficiency. Higher annealing temperatures also demonstrated higher efficiencies and at the highest temperature on my hotplate (455C), the efficiency was improved by around 45%. Use of a reflecting mirror did not show significant improvements in efficiency. There was also excellent agreement of the experimental data with the junction model, which would imply that efficiency is limited by interfacial defects between the TiO_2 and front contact.

Conclusions/Discussion
An optimal device would be cost-effectively sealed to preserve the liquid electrolyte and use high concentrations of dyes that cover most of the visible light spectrum and can easily transfer electrons to the TiO_2. It may be possible to incorporate a material between the TiO_2 and front contact to reduce defects and lead to a higher efficiency.

Summary Statement
This project is a study on the prevention of degradation, understanding of the current-limiting mechanism, and improvement of electronic transport characteristics of a typical dye-sensitized solar cell.

Help Received
Received feedback on poster and presentation from Dr. Rocklin (high school physics teacher)