Extending the Operational Lifespan of Dye Sensitized Solar Cells

By: Susie Pan and Hillary Dawkins

Background

With the continued use of fossil fuels, global warming has become a major concern in today's society. Therefore, the aim of this project is to address the current need for alternative energy sources. Silicon-based solar cells claim to be "environmentally friendly" yet they produce toxic waste materials during the manufacturing process, and require 99.999% pure silicon which is difficult and costly to extract [1]. A promising new alternative for solar energy is dye sensitized solar cells. DSSCs produce a current using natural plant dye pigment, and therefore have no toxic waste materials [2]. Currently, experiments are being conducted all over the world trying to increase the solar conversion efficiency of these solar cells; but what good is a high current reading if it cannot last? This experiment investigates ways to prolong the operational lifespan of DSSCs in the quest to make these cells commercially viable.

Purpose

DSSCs hold a promising future, but are not currently suitable for commercial use due to their short lifespan. The three main factors that affect the lifespan of DSSCs are bacterial growth on the dye pigment, evaporation of the liquid electrolyte, and the decrease in efficiency due to photobleaching [3]. Experiments were conducted to either inhibit bacterial growth on the dye pigment by adding benzoic acid as a preservative, or to prevent evaporation of the iodine electrolyte by using several sealing agents. Lastly, the best results for the two experiments were combined to form hybrid cells.

Hypothesis

It was hypothesized that the modified cells containing benzoic acid or sealing agents would maintain their initial current readings over a longer period of time than the control cells. In the case of the preservative experiment, it was predicted that adding the benzoic acid to the dye would be most effective, as this method dissolves the preservative most effectively. Furthermore, it was predicted that all sealing agents would have a positive impact on the lifespan of the cell, due to their ability to prevent evaporation of electrolyte. Finally, the combination experiment was predicted to exhibit the best of results from the two previously conducted experiments: an extremely high initial current, with a prolonged lifespan.

Procedure

Firstly, to prolong the effectiveness of the dye, benzoic acid was added to the solar cells. The preservative was added to two varieties of dye, using three different methods, and experimenting with three levels of molar concentration. The modified solar cells were observed for a time period of 240 hours, with voltage and current readings taken every 24 hours. Fig. 1 summarizes the design of the first experiment.

Secondly, to prevent the evaporation of the liquid electrolyte, Crazy Glue, tape, and hot glue were each used to seal the cells. To determine the effectiveness of each sealant, cells were observed over 10 days in the same way as the benzoic acid cells. Fig 2 summarizes the design of the second experiment. In both experiments, the modified cells were compared to the control cells made with no benzoic acid or sealing agent.

Finally, using a combination of the best results of the two previous experiments, cells made with blackberry dye extracted with ethanol were constructed and sealed. These new hybrid cells were observed in the same manner over a time period of one week. Fig 3 summarizes the design of the third experiment.

Fig. 1: Design of Experiment #1

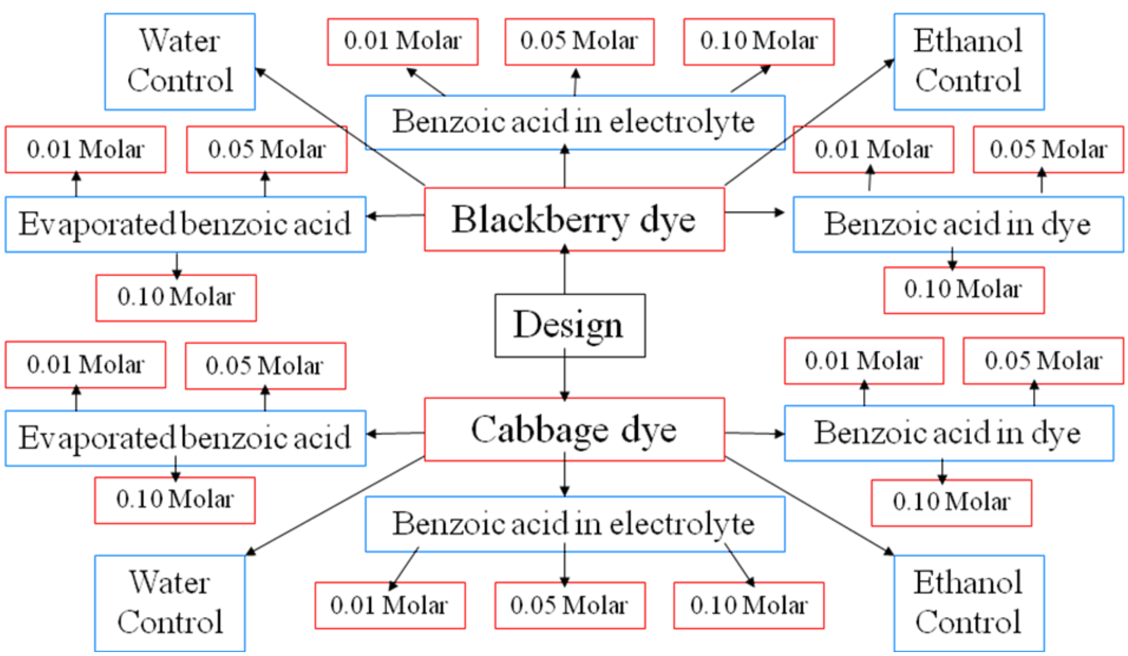


Fig. 2: Design of Experiment #2

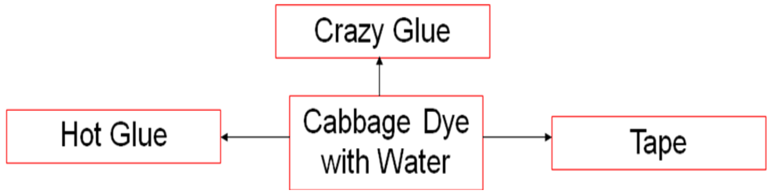
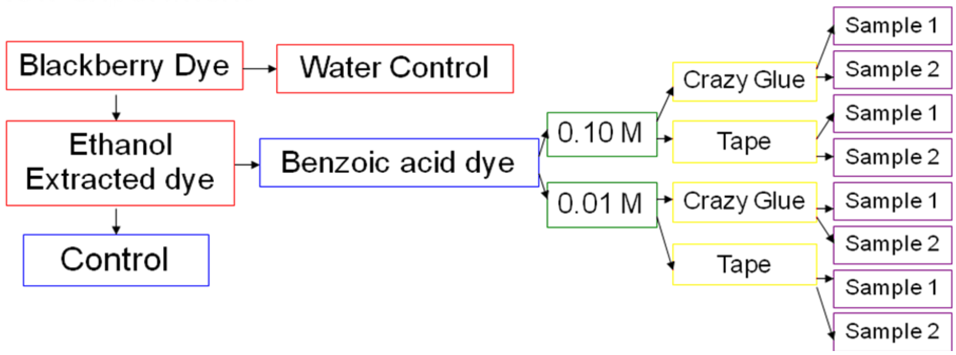
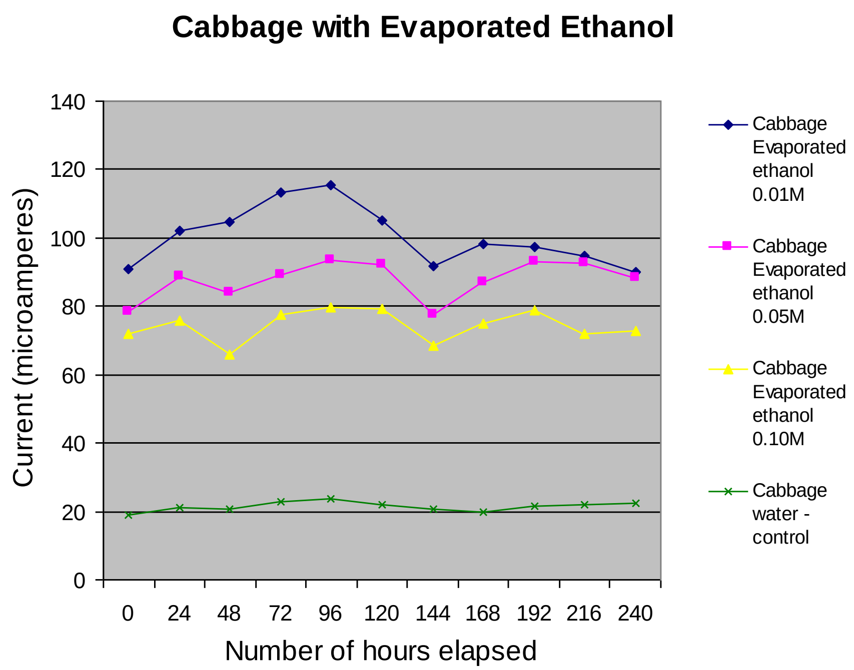


Fig. 3: Design of Experiment #3



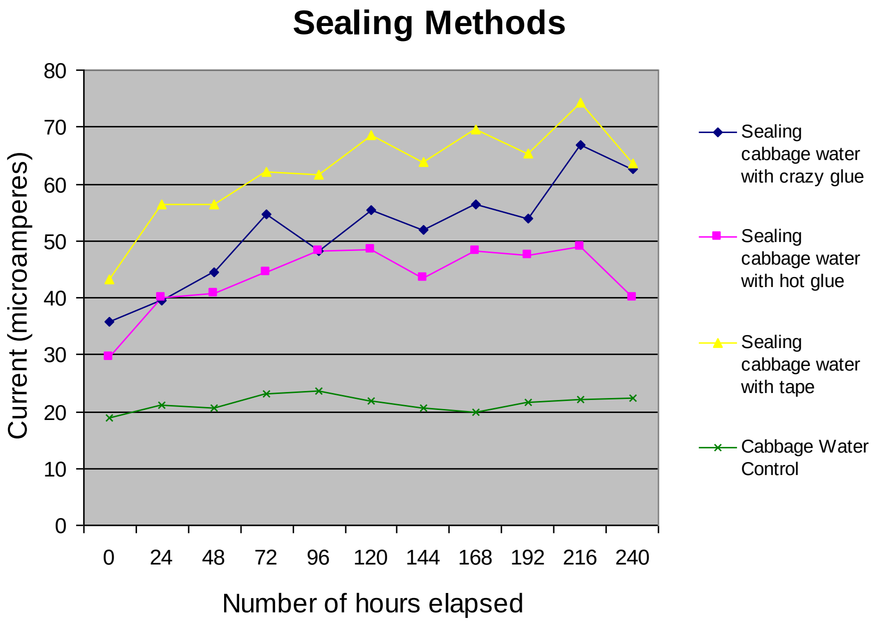
Results and Observations

Fig. 4: Sample Graph of Experiment 1



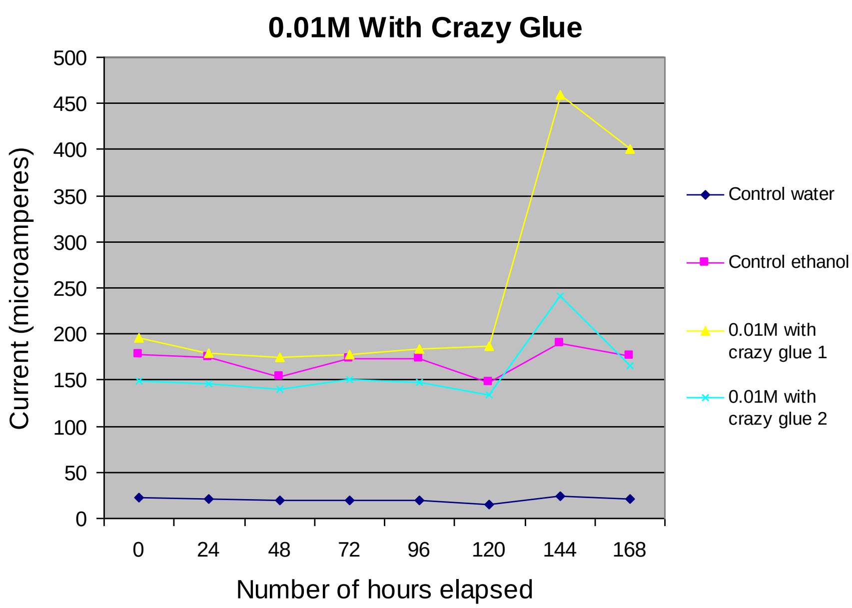
This graph represents the current readings of the cells made with cabbage water dye, with the addition of benzoic acid through the evaporation of ethanol. The cells made with benzoic acid produced higher initial current readings than the control cell. All cells maintained their initial current readings over the experimental period of 240 hours.

Fig. 5: Graph Summarizing the Results of Experiment 2



This graph represents the current for the cells that were sealed with crazy glue, hot glue and tape compared to the cabbage dye with water control. It is evident that the cells which are sealed worked better then the control as the current was higher, but also steadily increased while the control remained constant. By the end of the 240 hours, all three of the sealed cells' current readings were higher than their initial current.

Fig. 6: Graph Summarizing the Result of Experiment 3



This graph shows the current readings of the cells made with blackberry ethanol extracted dye with sealing agents, as compared to the blackberry water control. The modified cells exhibited higher current readings than the control. All cells maintained their current readings over the one-week time period. A major peak occurred after 166 hours; an identical experiment is currently being conducted to determine if this peak can be reproduced.

Conclusions

Experiment #1 with the benzoic acid produced a wide range of results. From the data, it was concluded that the cabbage dye made with water and the addition of benzoic acid through evaporated ethanol worked the best. The benzoic acid cells exhibited dramatically higher current readings than the control cell, and maintained the increased current over the entire duration of the experiment (Fig. 4). On the other hand, the blackberry dye made with ethanol and benzoic acid produced extremely high initial current spikes, but dropped off drastically as time elapsed. From the data and the analysis, it was concluded that the addition of benzoic acid has a variety of impacts on the dye pigment, and lifespan of DSSCs, depending on where the benzoic acid is placed. In this experiment, the concentration seems to have no major effect on the results.

Furthermore, it was concluded that sealing methods play a major role in the operational lifespan of the solar cell. Over the 240 hours, it is evident that using different sealing agents such as crazy glue, hot glue, and tape around the edges of the solar cell, all produce increasingly high current readings as compared to the control (Fig. 5). This result can be attributed to the reduced evaporation of the iodine. Sealing the cell allows the liquid electrolyte to be preserved for a longer period of time, thus increasing the cell's overall lifespan.

Finally, the investigation into the combined effects of blackberry ethanol extracted dye and sealing agents showed positive results. The cells produced radically higher current readings compared to the control, and maintained those increased current readings over the total time period of one week (Fig. 6).

Acknowledgment

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APPENDIX

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